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ANNUAL REPORT - 1955

FOREST RESEARCH IN CALIFORNIA

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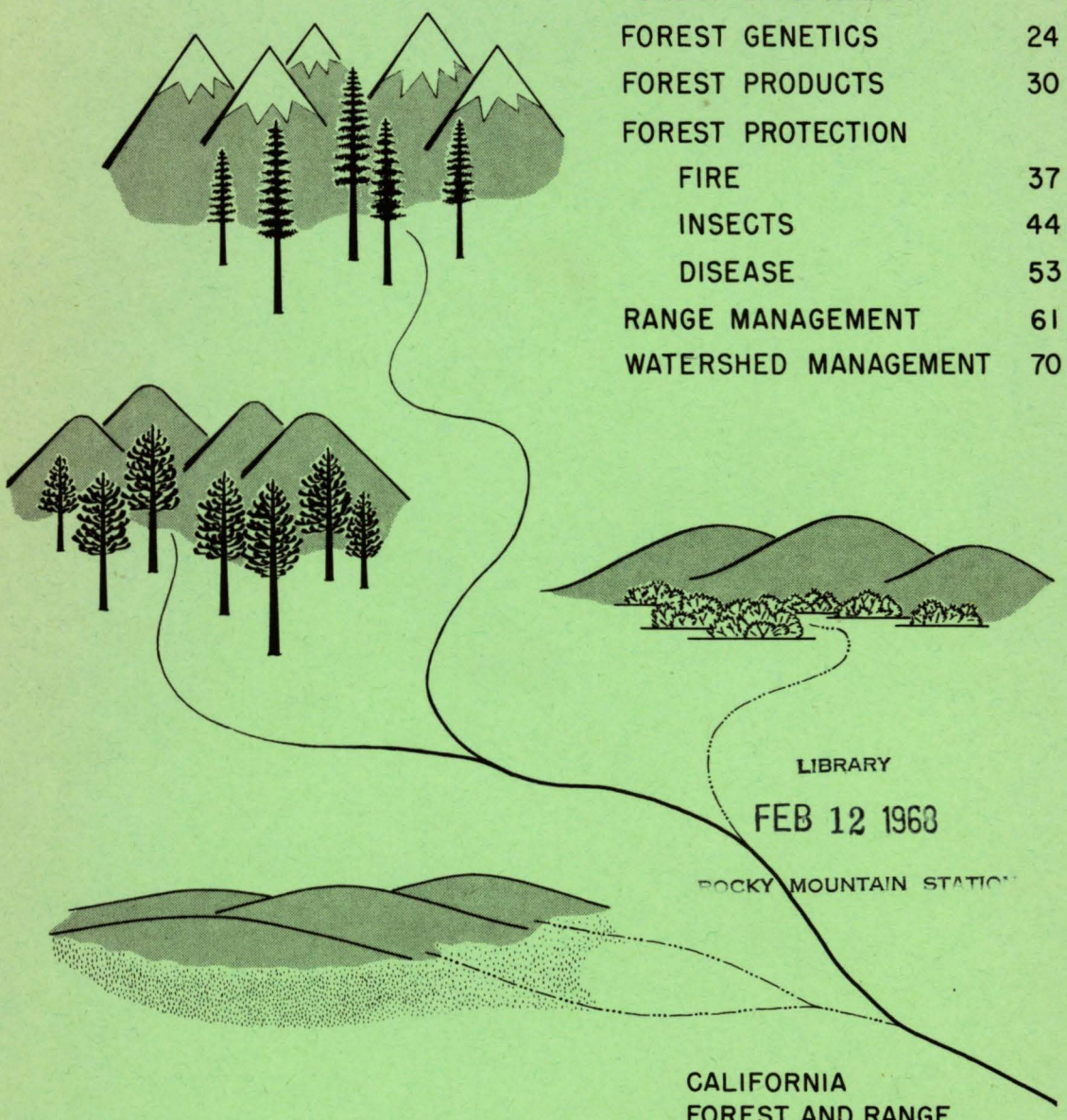

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CALIFORNIA
FOREST AND RANGE
EXPERIMENT STATION
GEORGE M. JEMISON, DIRECTOR

FOREST SERVICE — U. S. DEPARTMENT OF AGRICULTURE

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INTRODUCTION

California's tremendous growth has been impressed on the people of the state with increasing regularity and emphasis in the last few years. We have learned that the rapid upswing in population that has swelled our numbers to about 13 million will continue. In 15 or 20 years we probably will have 20 million people in California--more than any other state. Favorable climate, labor supply, and natural resources, singly or in combination, have given rise to a tremendous growth of industry and agriculture. The personal income of Californians is now more than $27 billion per year, or almost twice as much as that of the other 10 western states combined. This growth has created many problems relating to the development and use of water, timber, and forage from the forest lands of the state. We are becoming increasingly conscious that solution of these problems is a "must" for future prosperity.

Water-supply and flood-control problems, capped by the devastating year end flood, have been especially prominent in the public eye during 1955. The recent flood disaster in northern and central California, due to highly abnormal combinations of intense and prolonged rains, cannot be easily exaggerated. As important as the flood-control problems are, Californians are not overlooking the ever-present water-supply problems. During the year the Feather River Plan--a $1\frac{1}{4}$ billion project--has drawn strong criticism as well as approval throughout the state. Its values for flood protection are now being emphasized as are those of other projects in the Sacramento, San Joaquin, and North Coast regions. This year the United States Congress approved construction of the Trinity River project, which will divert water from the Trinity River into the Central Valley system. The "counties of origin" debate continued and we can expect no great progress in any state-sponsored program of water development until the rights of upstream and downstream water users are clarified. During the year there has been a great deal of discussion about forming a Department of Water Resources to bring together responsibilities for water development and use now divided among more than a dozen state boards and divisions.

The State Engineer has emphasized that the ultimate firm supply of water required in California probably will be $2\frac{1}{2}$ times the present safe supply, or about 50 million acre-feet a year. The present developed supply of 24

million acre-feet includes an annual overdraft of about 3 million acre-feet. With an average annual streamflow for the whole state of 71 million acre-feet, we will be hard put to provide firm supplies in the amounts ultimately needed without very extensive and very costly water control and distribution projects.

It is plain that making the most of the annual streamflow is going to require increasing attention to the way we treat the timber, brush, and grasslands of the state. These lands yield 95 precent of our streamflow. The commercial forest zone alone produces 70 percent of our water supplies. The importance of protecting and managing these watersheds cannot be overemphasized. The 9 million acres of commercial forest lying in the zone of heavy snowpack deserves special attention because it produces about 40 percent of the water yield. In some states, past research has turned up good evidence that the timber cover can be managed so as to increase the quantity of water or regulate the snowmelt. This year the Station was able to begin a new project which will explore this phase of water production and control. The long-idle Teakettle Creek Experimental Watershed in the north fork of Kings River was reopened. The Central Sierra Snow Laboratory near Donner Summit was transferred to us by the Corps of Engineers and some work will be started there. We hope that this start, though a modest one, will contribute considerable information on the more important water problems in the state.

Continued attention has been given during the year to soil stabilization problems, and the fundamental research program at the San Dimas Experimental Watershed in southern California has continued. Several additions to the technical staff have greatly strengthened the group working on these projects.

The national Timber Resource Review and a strong demand for forest products locally emphasized the importance of California's timber supply. The T.R.R., released by the Forest Service in October, sets forth the national timber situation and outlook in considerable detail. Viewed against the national picture, California's 360 billion board-feet of sawtimber represents a sizable resource. It amounts to 18 percent of the national supply although we have only 3.6 percent of the commercial forest land. Locally the lumber industry continued to boom and our annual cut stayed well over 5 billion board-feet. Veneer, poles, piling, and other products are also being produced at record levels. Interest in the expansion of the State's small pulp and paper and hardboard industry greatly increased during the year.

With 360 billion board-feet of sawtimber, California can continue to supply a big and healthy timber industry. But there are some problems to be overcome and many opportunities to do a better job in growing and utilizing timber crops. The Forest Survey of California shows that net annual growth was 2.9 billion board-feet, but mortality to live sawtimber caused by fire, pests, and weather totalled another 1.9 billion board-feet in 1952, not an abnormal year in any respect. There are areas with sawmill capacity far in excess of the ability of the forests to supply raw material permanently. Here, industrial diversification and better utilization are needed. In spite of great progress in the past few years, utilization of logging residues is poorer in California than in any other region. Large timber, heavy stands, defect, and steep terrain combine to make logging and intensive utilization costly and difficult in California. There is an opportunity, however, to supply part of our future needs for wood from sources now not utilizable. Research can contribute by developing better methods of logging, better cost and return information, and more accurate measures of growth, cull, quality, and yield. Unfortunately, we in research are not coming close to answering adequately many of the most pressing timber management and utilization problems.

Wood residue concentrated at primary wood manufacturing plants also offers an opportunity for industrial expansion without increased timber drain. This material constitutes a major but as yet little-used source of wood pulp. The T.R.R. shows that the state produced 372 million cubic feet of plant residue in 1952 but used only about 40 percent of it, mostly for fuel. Only 8 million cubic feet were used for fibre. Recent trends have probably improved utilization, but there is plant residue available to support several pulp mills in the state.

Unproductive forest land represents still another place where we can broaden the raw material base. There are 4.1 million acres of plantable commercial forest land in California. Probably about half of this represents medium to good sites capable of producing good growth and quality timber. Reliable methods of forest regeneration are yet to be found, but we are making some headway. Some findings in 1955 suggest ways to make regeneration more successful. Also, our forest tree improvement research program has made significant progress. We have been studying the economic feasibility of mass-producing several pine-hybrids which have performed impressively in nursery and field tests. Results of mass-production tests give considerable promise that commercial production and use of these hybrids will be practicable and hence that they may

become the basis for an improved tree-planting program. One of the immediate needs is for public and private agencies to work with research groups in conducting an expanded mass-production testing program and in using its products in reforesting idle forest lands. California's idle acres, if stocked with superior trees, will help sustain a prosperous timber industry in the future.

Better management and utilization of forests can make their full contribution to the State's growth only if we learn to protect the forests from losses due to fire, insects, and disease. In 1955, fire losses were brought home to everyone. The fire season was dubbed the worst in recent California history, and such names as Refugio, Hacienda, McGee, and Haystack became common knowledge through newspaper accounts of the fires they designated. During 18 disastrous days, 436 fires were started. In spite of unprecedented fire weather, federal, state, county, and private forces controlled more than 300 of them at 10-acre size or smaller. Only 41 fires burned more than 300 acres each. Nevertheless, the costs and damages were tremendous. Between August 27 and September 13, the record showed:

307,000 acres burned
1½ billion board-feet of timber killed
6 lives lost
$4,000,000 worth of physical property destroyed
$3,610,000 expenditures for control
Undetermined watershed and soil values lost

California's fire problem is characterized by high losses during exceptional periods. Somehow ways must be found to meet these extraordinary situations. Research can help. During the past year our fire research activities have been expanding with the help of several agencies. We are making progress on the study of chemical fire retardants and in the use of aerial delivery. A new and detailed study of wind movement in mountain areas was started. For the first time a research project on prevention of man-caused fires is underway. Finally, with the help of the University of California, a fire research laboratory was established and partially equipped to aid in study of some of the more baffling aspects of forest fire behavior. Progress is being made but much remains to be done.

Losses from forest insects and disease, less spectacular than from fire, are substantial. Insects kill more timber in the state than all the other agents combined. For example in 1952, insects killed an estimated 1.4

billion board-feet of live sawtimber, about one-fourth as much as was cut for all uses that year. During the past year losses continued although land managers are reducing bark beetle damage in pine forests, primarily through the logging of over-mature or weakened timber.

Some real obstacles to the control of insect losses still remain. We need more effective ways of controlling insects in recreational areas such as Yosemite National Park, where the lodgepole pine needle miner and the mountain pine beetle are teaming up to destroy the timber on valuable scenic areas. Perhaps biological control methods or better chemical sprays applied from airplanes will be the answer. Several parts of the state are still plagued with bark beetle problems and flathead borers. We need to learn more effective control methods and for some tree species how to recognize the individual trees most susceptible to insects. Cone and seed insects are a major factor in preventing satisfactory natural regeneration of cutover areas but little or no research is underway on this problem. At the year end we have added a man to our staff to resume work on the development of insect-resistant trees. Some very promising leads will be followed up.

Although the full impact of forest diseases on timber growth is hard to evaluate, we know that heartrot in over-mature timber accounts for the greatest losses due to diseases in the state. It is estimated that 80 to 100 billion board-feet of timber is unusable today because of this rot and must be culled from timber harvests. Some evidence indicates that removal of over-mature trees will not solve the cull problem entirely. This year we began a study of heart rot in relation to environment so that we may point to a type of management in the future where heart rots may be kept at a minimum. A new study of the ecology of ribes and the behavior of the white pine blister rust fungus was started during the year. This investigation will pinpoint where ribes eradication is most necessary and where conditions are unfavorable for blister rust development and spread.

Accurate evaluation of the importance of forest diseases in the state has been restricted because of lack of information on the number, extent, and activity of these destructive agents. At mid-year a disease survey was organized and a pathologist assigned to begin a systematic study and survey of our disease problem. This program should put both disease research and control activities on a sounder basis.

Demands for range forage have risen along with the pressure for more water and timber from the State's wild land. In January 1955 California had 3.6 million cattle and calves, the greatest number in the past quarter century, and 77 percent more than in 1930. This high inventory puts the state in ninth place nationally but first among the 11 western states. In beef cattle numbers California ranks tenth nationally and second among the 11 western states. Sheep have been increasing since 1950, when they hit a 25-year low, although the 1.8 million sheep now in the state are only 55 percent of the 1930 inventory.

The effect of these trends on the range has been to increase the livestock grazing load about 43 percent in the past 25 years. This increase is more significant considering the gradual reduction of rangeland because of other uses, the encroachment of brush on some areas, and the increase in big game animals. California now has more deer--1.1 million--than any other western state and twice as many as Oregon, which ranks second among the western states in deer numbers. Two-thirds of the deer grazing load is carried by the national forests in California. These areas also provide half a million animal-unit-months of livestock grazing per year.

Some progress is being made in solving the many rangeland problems. The success of the Burgess Spring range-research program, related in previous annual reports, is emphasized by the current Harvey Valley range management pilot test in Lassen County. There, practical range management based on earlier research is being demonstrated. It is estimated that grazing capacity of the allotment will be doubled in about 15 years. With the assistance of the California Fish and Game Department, some progress is being made on investigations of deer habitat improvement. Converting brushlands and managing vegetation on improved ranges is still a complicated job but we are making progress on it in some of the foothill areas. Taken all together, however, our research program in range management is not fully meeting the demands for more and better information.

When we take an overall look at where we are and where we are going in the development and use of the State's forest and range resources, several things stand out. First, with the growth of California these resources will be in increasing demand. More opportunities to utilize them profitably will arise. But at the same time more problems will come up. As forest and range lands become more intensively used for timber, water, livestock,

and wildlife production, and for recreation, there will be areas of conflict. We will find it increasingly difficult to get the greatest production of two, three, or all of these products from the same acres. Research organizations have a big task ahead of them to foresee the problems and have solutions ready when they are needed.

Adequate solution of timber, range, and water problems will be the only effective basis for attaining the greatest and most satisfactory integration of all efforts to produce these resources. Research can and is helping move toward these goals. In the following pages are reported some of the specific accomplishments of the year.

FOREST ECONOMICS RESEARCH

INVENTORY REPORT BOOSTS DEVELOPMENT OF FORESTS

Publication of the Forest Survey report for California has greatly stimulated interest in the timber resources of the State. Approximately 2,500 copies of this report, "Forest Statistics for California," were distributed in 1955, and requests for copies and additional information are being received daily.

One particularly encouraging development has been the increased interest in fibre-producing possibilities. Several nationally known pulp and paper companies have begun surveys to determine the feasibility of establishing plants in California. The volume of woods and mill residue left in producing lumber and veneer could provide raw material for several large pulpmills. Hardwoods and thinnings from second-growth stands of conifers could provide additional raw material; furthermore, harvesting this material would improve growing conditions for the residual stands.

The Forest Survey report also provided much of the California data for the national Timber Resources Review. This detailed review of the forest situation in the United States drew on the Forest Survey for information on forest area, timber volumes, timber growth, and industrial use.

The Review shows that although California's 17.3 million acres of commercial forest land is only 3.6 percent of the Nation's total, the State's 360 billion board-feet of standing timber is 18 percent of the Nation's sawtimber volume. Nearly one-fourth of the old-growth sawtimber in

the United States is in California and the State produces one-sixth of the Nation's lumber.

TIMBER REINVENTORY PLANNED FOR STATE

Forest inventories soon become out of date as a result of timber cutting, fire, insect and disease losses, land clearing, and timber growth. The net changes can be approximated by estimating the effect of these factors and adjusting inventory figures accordingly, but the adjusted figures may be badly distorted and of little value if the estimates are extended over a number of years. To maintain an up-to-date record of our forest situation periodic reinventories are necessary. The national Forest Survey program provides for reinventory every 10 years in the Pacific Coast states. Since the original Survey in California began in 1946, we are now making plans for the reinventory of the State.

Sampling methods, accuracy standards, and field procedures used in the original survey are being carefully reviewed and revised. During the year the efficiency of several sampling designs was tested in cooperation with the Intermountain Forest and Range Experiment Station and the Washington Office of the Forest Service. The Forest Survey staffs of three western forest experiment stations met in Portland in October to discuss survey standards and techniques and to pool experience in survey methods. These tests and discussions contributed materially to the improvement of survey procedures.

The adequacy of the Forest Survey to meet the needs of the timber industry, trade associations, and public agencies is also being studied. Several persons and agencies have stressed the need for more detailed local information. To meet this requirement, the tentative plans for reinventory call for developing estimates of forest area and timber volume by individual counties.

ECONOMICS OF GRASS VERSUS TIMBER STUDIED IN HUMBOLDT COUNTY

In recent years ranchers in the northern coastal counties of California have been faced with a difficult economic decision--whether to cut over their Douglas-fir timberlands and convert them to grass or to manage these areas for timber production. Before World War II there was little or no market in this area for Douglas-fir, and timber stands frequently were cut and burned to provide more pasturage. Since the war, however, the rapid increase in the demand for Douglas-fir has pushed up stumpage prices so that the timber stands are valuable assets to the ranch property.

Livestock rancher in northern Mendocino County has successfully converted this once-timbered area to grass.

The brush-covered hillside in middle distance is the result of an unsuccessful attempt to clear timbered area for grazing in Humboldt County.

A number of ranchers are beginning to question the wisdom of attempting to convert these areas to grass. Timber production may be more profitable than sheep raising.

To aid land owners in making this decision, the Humboldt County Forestry Committee asked the Station's assistance in determining the relative returns that can be obtained by alternative uses of these areas. During the year a start has been made on this problem.

In cooperation with the Agricultural Research Service, the Humboldt County Farm Advisor's office, and the County Forester, field studies have been made on a number of ranches in southern Humboldt County. Ranch owners have been questioned regarding costs and returns from clearing operations. Cutover areas have been examined on the ground. Field examination has been started to determine the grass yields of converted timberlands compared to natural grasslands.

Preliminary observations indicate that on suitable terrain and exposures the predominant Josephine and Hugo soils which supported stands of Douglas-fir and hardwood timber can be successfully converted to grassland. To be successful, however, the conversion process requires more than merely cutting and burning. It also requires careful range management over a number of years. Many attempted conversions have resulted in dense brush because of poor selection of sites or lack of sustained management. These areas contribute little or nothing to the farm economy.

Very few areas were found where owners were making deliberate efforts to maintain the cutover land in timber production. Some natural reproduction of trees was observed, but in most of the cutover areas poor seed supply, heavy rodent populations, hardwood competition, and browsing by sheep and deer proved to be serious handicaps to successful regeneration of Douglas-fir. Detailed research is urgently needed on methods of overcoming these handicaps so that owners can successfully reestablish timber stands on these areas.

MACHINE TABULATING SPEEDS SOLUTION OF FORESTRY PROBLEMS

Increased efficiency in Forest Service tabulating and record-keeping jobs has resulted from a program by which the Division of Forest Economics is developing forestry applications of modern tabulating equipment. The Division maintains the only Forest Service machine tabulating installation in the West and, in order to fully utilize the equipment and skilled personnel, has encouraged other

Forest Service branches to bring their problems to this installation. The California Region has found that national-forest data on timber growth and mortality, timber cruises, mill scale studies, timber appraisals, and flight records can be computed by punch card methods at considerably less cost than by hand tabulating. Our tabulating unit is also processing Forest Survey data for the Intermountain Forest and Range Experiment Station. Within the California Station several divisions are using this equipment to tabulate research data, and our mailing list and labels are prepared with punch cards.

Other ways of using machine tabulating equipment to reduce time and cost are being studied. With the increasing size and complexity of the Forest Service program, more and more of the record keeping, fiscal control, and tabulating work will be handled by these modern business machines.

SOIL-VEGETATION SURVEY INCREASES MAPPING OUTPUT

The output for the second year's operation of the reactivated soil-vegetation survey shows an expected substantial increase as the newly recruited field and office workers have gained experience. Ultimately, this State-financed survey will map the kind and distribution of soils and associated vegetation on some 25 million acres of privately owned wild land. This kind of information is basic to the more intensive land management demanded by California's growth. To date nearly 4 million acres have been surveyed under the general coordinating direction of the Station in cooperation with the California Division of Forestry and the University of California.

Field crews mapped a total area of some 695,000 acres in 1955, 149,000 acres more than in the first year. Office workers have started an increasing flow of published quadrangle map sheets showing the soil-vegetation data and completed a generalized map of upland soils of Lake County.

Field mapping was in three counties: Tehama, 286,000 acres; Glenn, 100,000 acres; and Humboldt, 309,000 acres. The field survey in Glenn County is now complete and totals some 420,000 acres. In both Tehama and Glenn counties the field mapping was done jointly by Station and University workers; in Humboldt County by Station people alone.

Quadrangle map sheets at 2 inches to the mile scale were published for an area of 165,000 acres in Glenn, Humboldt, and Lake Counties. All of the Lake County sheets

are now completed for 179,000 acres in Tehama, Glenn, and Humboldt Counties so that sheets for this area can be issued early in 1956. These map sheets show contrastingly different kinds of vegetation and soil to a minimum area of 10 acres, the less contrastingly different kinds to 40 acres. Information about the soils and vegetation is tabulated to aid use of the maps.

The new map, "Upland Soils of Lake County," is the second of its kind so far published, the first being for Mendocino County. The Lake County map is being distributed by the State Printer. It shows on one sheet, 30 by 40 inches in size and of one-half inch to the mile scale, the different upland soils to a minimum of 40 acres. It also shows by different colors five general classes of land in the county, including those normally associated with conifer timber, grass and oak, or chaparral and minor conifers, those generally suitable for cultivated crops or pasturage, and miscellaneous land types generally unsuitable for timber, grass, or cultivated crops. A supplement tabulates some of the characteristics of the soils as well as estimates of their suitabilities for timber production and extensive range use.

NEW SURVEY STARTS IN FRESNO COUNTY

In August we started a soil-vegetation survey of the national-forest land in Fresno County, in cooperation with the Department of Soils and Plant Nutrition of the University of California and the California Region of the Forest Service. The survey will take about 3 years to complete and will cover about 900,000 acres. This is the first survey of its kind in areas of granitic soils. The upland soils mapped in Mendocino and Humboldt Counties were mainly on sedimentary rocks; those in Lake, Tehama, Glenn, and Colusa Counties mainly on sedimentary and volcanic rocks. The survey in Fresno County should add much to the present meager knowledge of upland soils on granitic rocks, which occupy extensive areas of wild land, particularly in the central and southern Sierra Nevada and the southern California mountains.

INTEREST WIDENS IN USE OF SOIL-VEGETATION DATA

A widening interest in combination surveys of vegetation and soil became evident during the year. Grass-roots interest was especially high in Humboldt and Sonoma Counties, both of which requested demonstrations of survey methods and of uses of the soil-vegetation data. As a result, a 3-day training session was held for range and forest technicians concerned with the management of Humboldt County wild lands, under the sponsorship of the

County Forester and the County Agricultural Extension Director. Also, two field days were held to explain the survey to ranchers in different sections of Humboldt County. In Sonoma County, where the survey has not yet started, a field day was sponsored by the Association of Soil Conservation Districts. Since the field day, a local committee has been working toward encouragement of an early start on soil-vegetation mapping in the County.

One entire session of the Division of Forest and Range Soils during the national meeting of the Soil Science Society of America at Davis last August was devoted to soil-vegetation surveys and their uses in wild-land management. Station workers and cooperators in the California soil-vegetation survey played important roles in this symposium. Afterwards field trips were taken into the Sierra Nevada and Coast Range mountains to observe some of the California work.

FOREST MANAGEMENT RESEARCH

FERTILIZER MAY INCREASE CONE CROP OF PINES

Sustained production of timber at a high level and the continued existence of a strong wood-using industry require that forests be renewed when the old growth is harvested. Hence, little proof is required to show that regeneration of forests is a subject of special importance to California, which still has mostly old-growth timber. During 1955, the Station has continued to emphasize research in regeneration by both natural seeding and artificial methods. Obtaining an adequate seed supply for natural regeneration at the right time on cut-over areas has always been a problem. Seed trees left on the cutting areas have not always met the demand. A small preliminary test on fertilizing sugar pine seed trees indicates that cone production may be increased with applications of ammonium phosphate.

In the spring of 1951, 8 paired sugar pines ranging from 27 to 52 inches in diameter were treated with 100 pounds of ammonium phosphate (16-20-0) per tree. The fertilizer was spread on the ground beneath each tree over an area equivalent to the crown width. The treatments were repeated in the spring of 1952 and 1953.

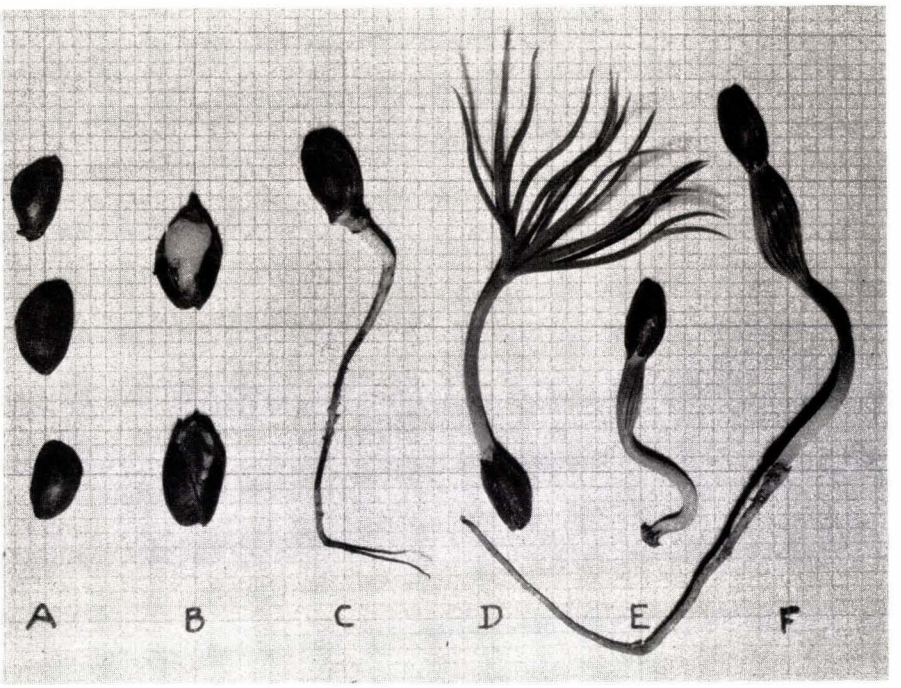
Since sugar pine cones require two years to mature, no effect of the fertilizer was expected until 1953. None of the trees bore cones in 1951. In 1952, 4 of the fertilized trees bore more cones than their unfertilized counterparts and 4 had less cones. In 1953 fertilized trees produced nearly twice as many cones, and the total cone production for the 3-year period 1953-55 was 3 to 1 in favor of the fertilized trees. The difference was particularly striking in 1955, when only 1 of the unfertilized trees bore a single cone, but 5 of the fertilized trees produced a total of 162 cones.

ABNORMAL SEEDLINGS PRODUCED BY IMMATURE SEED

Collecting pine seed too soon may cause planting failures. This is the lesson taught by a study of the effect of seed maturity, as measured by specific gravity of cones, on the viability of sugar, Jeffrey, and ponderosa pine seeds. The cones were collected in September and October 1952 and segregated into 4 specific gravity classes--2 lower and 2 higher than the specific gravity index of mature cones. The specific gravity of cones declines as the cones mature and dry. Ponderosa pine cones are ripe at about 0.86 and sugar pine at 0.80. Germination tests were made in the springs of 1953 and 1955. One of the main purposes of the study is to learn how long seeds of different stages of maturity can be held in storage. Little difference in retention of viability has shown up, except in sugar pine. But a great deal of abnormal germination was found to be associated with immature seed. As is often the case in experimental work, this discovery outside the main objective is the most important result of the study to date.

Abnormal seedlings included some which emerged from the seed in a reversed manner, some without roots, and some with their cotyledons tightly enclosed by the enlarged endosperm. If not recognized in advance of field or nursery sowing, the presence of a high percentage of seed that produced abnormal seedlings would result in understocking of the stand. The abnormal seedlings at first glance appeared to be normal, therefore they could easily be and probably have been overlooked many times in germination tests, giving a false impression of seed quality.

Abnormalities were observed only among seedlings derived from immature sugar and Jeffrey pine seed and occurred most frequently in fresh rather than stored seed. Nearly half of the sugar pine and a third of the Jeffrey pine seedlings from immature fresh seed were abnormal.



Normal and abnormal sugar pine seed and seedlings. A, normal sugar pine seeds; B, swollen seed, embryo dead. Embryo swells to unusual size when water is absorbed; C, cotyledons tightly enclosed by the enlarged endosperm; D, reversed germination (cotyledons instead of root emerge); E, seedling without root, F, normal seedling.

STORAGE TEMPERATURE DETERMINED FOR SEED OF THREE PINES

Coniferous seeds have always been stored in the past at 41°F. at the California Station. Results of a recent study indicate that 41°F. is not the optimum storage temperature for sugar, Jeffrey, or ponderosa pine seed.

Seed of these three species, collected in the fall of 1952, were stored in half-gallon cans with tight lids at 4 temperatures--0°F., 23°F., 32°F., and 41°F. The germinative capacities of the fresh seed were: Sugar pine, 98 percent; Jeffrey pine, 93 percent; and ponderosa pine, 86 percent. Germination tests conducted in the spring of 1955 indicated that the retention of viability was highest for sugar pine at 0°F., for Jeffrey pine at 23°F., and for ponderosa pine at 32°F. The germination percentages in 1955 were:

Storage temperatures	Sugar pine	Jeffrey pine	Ponderosa pine
0°F.	94	91	76
23°F.	84	93	78
32°F.	77	85	85
41°F.	6	84	76

Sugar pine seed stored at 41°F. lost almost all viability; however, for the other two species the difference between the best germination and that at 41°F. was only 9 percent. Tree seed is expensive and often difficult to procure. Seed of each species should be stored at the temperature which appears to be nearest optimum for that kind.

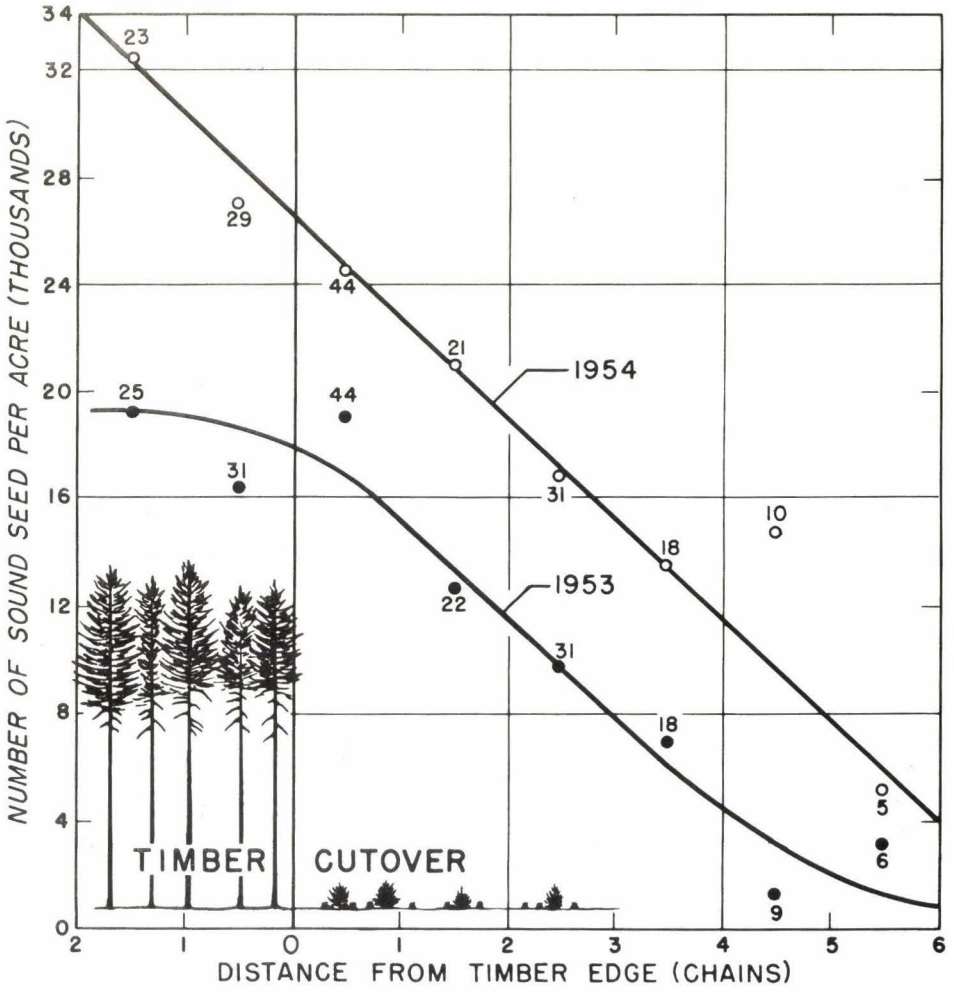
SEED FALL LIMITS SIZE OF DOUGLAS-FIR CUTTINGS

Preliminary information from a study in northwestern California suggests that relatively small cutover areas are best for forest regeneration in the Douglas-fir type there. Seed dispersal now has been recorded for 2 years in this study. Seeds have been counted from 173 seed traps (each with an effective area of 8.2 square feet) distributed evenly over two clear-cut tracts, one of 14.2 acres and the other of 13.3 acres. Both are on slopes facing east, but the average slope of the larger tract is 35 percent compared to 46 percent for the smaller one. Seed traps were also placed under trees on the timbered borders of the logging areas.

In 1953 the sound seed dispersed per acre averaged 18,500 under the timber and 11,800 in the cutover. And in 1954 seed fall under the timber and in the cutover averaged 29,500 and 19,000 sound seed, respectively. In both years seed fall in the cutover was 64 percent of that under the timber. The more important fact, however is that seed fall was reduced about 3,600 seeds per acre for each chain of distance from the timber edge. Information now available suggests that clear-cut blocks in the Douglas-fir type of California should be limited in size to 15 acres.

SALVAGE LOGGING DESTROYS DOUGLAS-FIR REPRODUCTION

Prompt salvage logging is advisable to avoid damage to natural Douglas-fir reproduction on burned areas, according to observations on a small part of the Three Creeks Burn in Humboldt County. The fire which killed the standing timber in August 1951 was followed by heavy seed-fall from undamaged timber nearby. An excellent stocking of Douglas-fir seedlings on the study area resulted. The ground has an eastern exposure and an average slope of 40 percent.



Douglas-fir seed dispersal, Brush Mountain unit, Six Rivers National Forest

In 1954, before logging, two sample lines were staked. The logging operator, who used conventional tractor logging methods, did not know that the lines existed, and therefore was not influenced by them. Logging removed an average of 41,800 board-feet (net) per acre.

Before logging, 71 percent of the sample quadrats were stocked with one or more seedlings and the total stocking amounted to 2,000 Douglas-fir seedlings per acre. After logging, only 25 percent remained stocked and Douglas-fir seedlings were reduced to 417 seedlings per acre. All sample areas had been disturbed by logging to some degree. Only 2 percent were disturbed lightly, but 34 percent were moderately disturbed and 64 percent were severely disturbed.

Those lightly disturbed were 100 percent stocked; moderately, 51 percent; and severely, 9 percent.

The most obvious corrective measure would be to salvage the burned timber immediately, before new seedlings appear. The possibilities for modifying logging methods to protect small seedlings are not promising.

CHEMICAL SPRAYS REDUCE BRUSH COMPETITION

Brush competition is one of the more serious obstacles to survival of both planted and naturally established trees in California. Recent trials with hormone sprays--2,4-D and 2,4,5-T--indicate that some brush species are completely killed while others, which are more resistant to chemical sprays, are retarded sufficiently to permit conifers to compete favorably with the brush that survived spraying.

As might be expected, young sprouts were easier to kill than older plants and the effectiveness of the hormone sprays varied with the brush species treated and the season of application. The results indicated that the foliage of all five brush species treated could be killed; however, many plants resprouted from the roots or aerial stems the year after treatment. Maximum crown area reduction and entire plant kill, 5 or more years after treatment, was:

	Crown area reduction		Entire plant killed	
	2,4-D	2,4,5-T	2,4-D	2,4,5-T
Species and age:	- - - - percent - - - -			
Mountain whitethorn				
Young sprouts	100	80	100	80
Old plants	40	58	20	20
Sierra evergreen-chinkapin				
Young sprouts	32	90	20	60
Old plants	18	90	0	20
Bearmat				
Young sprouts	90	--	90	--
Old plants	90	--	90	--
Greenleaf manzanita				
Old plants	100	95	100	90
Littleleaf ceanothus				
Old plants	100	100	100	100

The hormone spray should be applied at a concentration of approximately 3,000 parts pure acid equivalent per million parts of water in sufficient quantity to wet the entire leaf surface--about 200 gallons of spray solution per acre. Recommended chemical and date of application are:

Species and age of plant	Chemical	Application date
Mountain whitethorn		
Young sprouts	2,4-D	June
Old plants	2,4,5-T	October-November
Sierra evergreen-chinkapin		
Young sprouts	2,4,5-T	October-November
Old plants	2,4,5-T	October-November
Bearmat		
Young sprouts	2,4-D	September-November
Old plants	2,4-D	September-November
Greenleaf manzanita		
Old plants only	2,4-D	October
Littleleaf ceanothes		
Old plants only	2,4-D	August
Old plants only	2,4,5-T	June-November

SLOUGHING BARK IS HAZARD TO PLANTED DOUGLAS-FIR

Observations of Douglas-fir plantations show that bark falling from large Douglas-fir cull logs kills seedlings planted nearby. Beginning three years after logging, strips of bark as wide as half the log circumference and many feet long are shed. For example, the bark from a 5-foot, 10-log cull tree would cover almost 700 square feet and might smother 10 to 20 planted trees.

Areas shaded by logs are commonly recommended as desirable places to plant. However, when they are close to large logs which retain bark, they are hazardous for conifer seedlings and, therefore, should not be planted.

PLANTING PONDEROSA PINE IS A GOOD INVESTMENT

The need for well stocked forest lands to maintain California forest industries has created much interest in the financial aspects of forest planting. To help determine when planting ponderosa pine is a good investment, we made an analysis of the expected

returns from ponderosa pine plantations. The present value of expected returns from intermediate and final harvests was computed for different interest rates. Also, the cost of pruning crop trees was discounted to the present and subtracted from the present worth of the harvest. The results (table 1) show that the planted forest can earn attractive financial returns.

On managed forest properties fixed and current operating costs are not increased as a result of improving the stocking by planting. Consequently, the direct outlays for planting and pruning, and the interest charges against them, are the only charges that need to be assessed against plantation yields. Therefore the data in table 1 show the maximum amounts that can be spent for planting and site preparation and still earn the indicated interest rates.

Site preparation and planting now cost about $70 per acre for moderately difficult situations. At this rate, planting ponderosa pine would yield interest of 6 percent for site A-200, the most productive pine land in California. The same expenditure would earn 5 percent for site I-125, and less than 2 percent for site IV-100. The breaking point for 2 percent is between sites III-125 and IV-100.

POLE LADDER DESIGNED AT STATION NOW MANUFACTURED COMMERCIALLY

In order to facilitate climbing trees for installing poison blocks for porcupine control at Blacks Mountain Experimental Forest, a very light weight, sectional pole ladder was designed. It is constructed of jointed tubular sections with alternate steps similar to those on telephone poles. The upper end has a large hook for hanging over a tree limb. This ladder was described in detail in an article in the Journal of Forestry, Vol. 53, pp. 453-454.

The ladder is now being manufactured in slightly modified form by an industrial firm. Although originally designed for placing poison blocks, it is useful for climbing trees for any purpose.

AGE-CLASS DISTRIBUTION IMPROVED AT BLACKS MOUNTAIN

In California, most of the timber cut now is being obtained from old-growth. In the future it will come from the timber we grow. Managers are faced with the difficult problem of scheduling the cutting to provide an orderly arrangement of age-classes. The objective is uniform distribution of age-classes up to rotation age so that each year the same amount of timber can be harvested. A simple method of attaining this balanced

Table 1.--Present value[1/, 2/] per acre of intermediate and final harvest of ponderosa pine plantations

Site index[3/] (feet)	Present value at indicated interest rate						Rotation
	2%	2½%	3%	4%	5%	6%	
	Dollars						Years
60 (IV-100)	65	35					140
70	114	67	46	19			120
80 (III-125)	177	113	73	31			100
100 (II-150)	323	225	158	78	40		80
120 (I-175)		394	279	143	75	40	80
140 (A-200)			468	257	146	86	80

1/ Reduced by charges for pruning selected crop trees at the rate of 50 cents per tree, discounted to the present. The charges were: On site index 60--40 trees at 50 years = $20 per acre; on 70 and 80--40 trees at 40 years = $20 per acre; on 100 and 120--50 trees at 30 years = $25 per acre; and on 140--50 trees at 20 years = $25 per acre.

2/ Full earnings reduced 25 percent to take care of incomplete stocking and unsalvagable mortality.

3/ Site index at 100 years--ponderosa pine yield table. Site index 60 is poor quality, 80 is "medium" in productivity, 120 is good, and 140 is very high. Symbols in parenthesis indicate site quality according to Dunning, "A site classification for the mixed-conifer selection forests of the Sierra Nevada," California Forest and Range Experiment Station Research Note No. 28, 21 pp. (processed). Dec. 1, 1942.

distribution of age classes is being tried out at Blacks Mountain Experimental Forest as a part of the pilot-plant test of Unit Area Control. A regulated forest in which the annual cut equals the growth is one of the more important management objectives of this project, and the intensity of silviculture is aimed at a high level of growth. Forest managers who visited the experimental forest recently have been especially interested in the method we are using to achieve this objective.

At Blacks Mountain the naturally even-aged group arrangement of the forest will be maintained. Hence, the forest manager's chief problem in regulation is to schedule the cutting and regeneration to obtain the desired pattern of age-classes. At present there is too much timber over age 140 (predominantly 300 years or more) and under 75 years. Hence, the 75 to 140 ages are seriously scarce. This pattern prolongs the time that will be required before a fully regulated forest can be attained.

The plan is to convert the wild forest into a regulated forest by a combination of area and volume allotment. The natural mozaic of age-classes, stocking, and other condition classes is being used as the starting point for allocation of the cut. Cutting periods of 20 years have been chosen. Eventually the age-classes will be the same--20 years. Rotation age has been set at 140 years, although this probably will be reduced in the future.

The first step in preparing the regulation plan was to determine the cutting period in which the oldest advance growth would reach rotation age. From analysis of the age-class pattern it was then determined that equal areas could be harvested at rotation age or greater and regenerated in each of the ensuing cutting periods. Areas now supporting advance growth and areas to be regenerated before final harvesting of the advance growth were allotted to the sixth and seventh cutting periods of the first rotation and to the first five periods of the second rotation. The intermediate age classes were allotted to the fifth cutting period of the first rotation. The overmature timber plus its estimated growth was then allotted on a volume basis to the first four cutting periods.

The method of regulation and all other management activities for the Blacks Mountain E perimental Forest are being prepared for publication by the U. S. Department of Agriculture.

FOREST MANAGEMENT PROBLEMS OF REDWOOD REGION ARE DEFINED

Redwood forests have never been the subject of sustained, systematic research, although some research has been and is now being done. Field work recently was completed for a survey of forest management research activities, past and present, in the redwood region. Altogether, 35 organizations were contacted. The purpose of the survey was to determine what information on redwood management is now available and what further research is desirable. It is a first necessary step in the research which the Station is beginning in the redwood region. Although focused chiefly upon redwood, the study was not limited strictly to that forest type but included associated tree species and intermingled types such as Douglas-fir.

Unquestionably, a forest management tool urgently needed for the redwood region is a site classification with yield tables. Sound business management of forests depends upon the ability to forecast future growth. Filling this need deserves high priority in a redwood research program.

An individual tree vigor classification by which growth after logging could be predicted is a second important subject for which many foresters expressed a desire for information. A good vigor classification would serve as a sound basis for cutting methods. Data on growth after logging for a study of growth response can be obtained relatively easily because many organizations have established permanent growth plots and have indicated willingness to pool information.

Techniques of managing second-growth stands to obtain maximum yield in terms of profit need immediate study. And no one is satisfied with the present knowledge on regeneration of forest stands. Redwood foresters also are interested vitally in other subjects which are narrower in scope. Some of these are:

(1) Slash disposal--how should slash be handled?

(2) Windthrow--how can stands be cut to eliminate or minimize windthrow in the residual stand or adjoining uncut area?

(3) Marginal logs and chunks--which pieces can be utilized profitably in salvage logging?

These problems and others facing the managers of redwood forests should be used as a guide in prosecuting an active forest management research program.

FOREST GENETICS RESEARCH

NEW STUDY SEEKS TO KNOW WHAT PONDEROSA PINE IS

A new study of geographic variation in ponderosa pine was started this year as the result of a grant from the Forest Genetics Research Foundation. Its objective is to determine the nature and extent of variation in form and function for this species. Foresters and botanists have known for more than a century that trees called ponderosa pine are not all the same from one region to another. Trees of the so-called Rocky Mountain and Arizona varieties have obvious characteristics which distinguish them from both the Intermountain and Pacific Coast forms of the species. Better knowledge of the kinds and ranges of variations in this species has great practical as well as scientific value. It can aid foresters interested in acquiring the best possible seed for reforestation. And it can guide tree-breeders desiring to produce the best trees for use in a certain place or for particular purposes.

An earlier study, started more than 40 years ago at the Priest River Experimental Forest of the Intermountain Forest Experiment Station, provided a good deal of information about the way ponderosa pines vary in form, structure, and growth performance. The samples used in this earlier study, however, represented the vast range of the species incompletely. Also, the study was designed to provide information only on the way sample pines performed in northern Idaho. This new study will encompass the complete range of the species in the United States and Canada, and it will yield information applicable to all regions where the species occurs naturally.

Widespread cooperative efforts of administrative and research foresters is helping make this project possible. Federal, State, private, and Canadian cooperators established more than 130 permanent plots during the fall. The plots, located at 1,500-foot elevation intervals along latitudinal transects, sample the entire range of the species from the Pacific Ocean to the Great Plains and from south-central British Columbia to the Mexican border. Thus, we will be able to compare trees growing at the same elevation in different latitudes, or at different elevations in the same latitude.

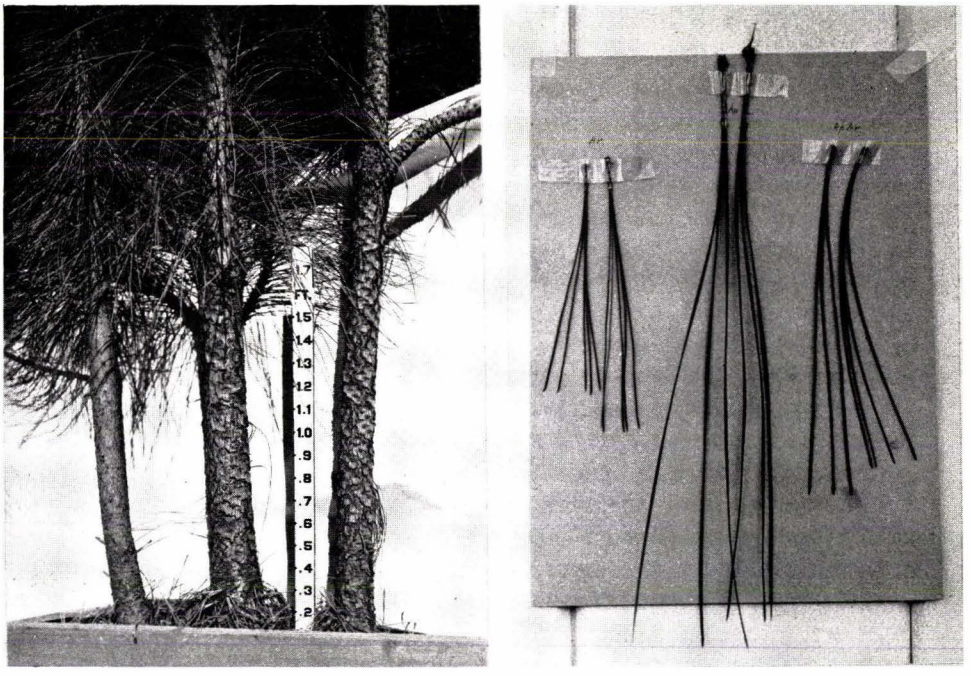
On each of the plots, cones and samples of foliage, bark, and wood were collected from each of 10 trees. Study of these specimens is already fairly well advanced, and some striking geographical variations in morphological characters have shown up. Geographical variation in physiological characters will be studied during the 1956 growing season. These studies will include investigation of (1) the rate at which seeds from different locations germinate under various conditions; (2) the rate of root penetration during the growing season; (3) the growth period under different conditions of day length, day and night temperatures, and moisture regime; and (4) adaptation to different soil conditions.

HEREDITY OF CHARACTERS PROVIDES BREEDING FORMULAS

Forest genetics is a young science and has a meagre store of basic knowledge, particularly with respect to the hereditary behavior of the characteristics which set different species or varieties apart. Knowledge of inheritance of characters is essential to efficient tree breeding. When obtained, it will be the basis for formulation of breeding procedures to achieve specific objectives. Practically any character or capacity of a tree may affect its survival or economic worth. Therefore geneticists seek information about the inheritance of even the most unimportant-seeming properties. Knowledge of any one of them may prove to be a vital genetic tool.

As pine-breeding results have accumulated, considerable information about the heredity of pine characters has been obtained at the Institute of Forest Genetics in recent years. Some knowledge of hereditary behavior has been obtained for several characters, including the following:

Earliness of fascicle production
Number of needles per fascicle
Length of needles
Coarseness of needle (size in cross-section)
Length of fascicle-sheath
Earliness of bark-scale formation
Shoot color
Growth rate
Disease resistance
Drought resistance
Frost resistance
Insect resistance.



The Apache-Arizona hybrid is like one parent in bark character, is intermediate in needle characters. Left to right, both photos: Arizona pine, Apache pine, hybrid. All 6 years old.

A single hybrid, Apache pine x Arizona pine, has yielded partial information about the inheritance of several of those characters. Its needles are longer and coarser than those of Arizona pine but shorter and finer than those of Apache pine. It is intermediate between the parents in rate of early diameter growth. In shoot-color it resembles Arizona pine. The hybrid has the Arizona pine propensity for producing 4 and 5 needles per fascicle and Apache pine's propensity for early formation of bark scales. Earliness of bark-scale formation is one of the characters with probable practical importance. Thickening of bark and production of scales may give young tree seedlings some protection against fire and possibly against the highly dangerous pine reproduction weevil, which seems to prefer young trees with thin bark though the insect has attacked pines which had passed the juvenile stage and developed distinct bark scales. That early formation of bark scales may not be conditioned solely by rapid diameter growth is suggested by comparison of the hybrid and an Arizona pine of the same age at the Institute. Taller and greater in diameter than the hybrid, the Arizona pine has smooth bark. Though more evidence is

needed, we are encouraged to believe that it will be possible to breed for this character.

YOUNG HYBRIDS DEMONSTRATE FUTURE OF IMPROVED TREES

The three-way hybrid, ponderosa pine x Apache pine x Montezuma pine, continued in 1956 to show the possibilities for improvement of forest trees by applying the results of forest genetics research. In its third year it outgrew its ponderosa pine check in the nursery at the Institute; average heights were as follows:

	Hybrid	Ponderosa pine
	- - - - (inches) - - - -	
At 1 year	2.8	3.3
At 2 years	14.9	10.0
At 3 years	31.0	21.0

Another three-way hybrid, (Jeffrey pine x Jeffrey pine x Coulter pine) x ponderosa pine, performed similarly. The height data for this hybrid and a ponderosa pine progeny from a highly vigorous ponderosa pine were:

	Hybrid	Ponderosa pine
	- - - (inches) - - -	
At 1 year	4.8	3.8
At 2 years	15.1	11.5
At 3 years	31.3	26.5

Both hybrids are growing faster than ponderosa pines native to the site which were tested in a study of elevational variation in that species at the Institute of Forest Genetics. But what of their future? Visitors often ask this question when they see fast growing hybrids in the nursery at the Institute. Final answers to such questions must await results of field trials. Nevertheless, an inkling of what may sometimes be expected is provided by the performance of some pine hybrids at Placerville and vicinity.

At 2 years, ponderosa pine x Apache pine is almost as tall as, and much greater in diameter than ponderosa pine. Thereafter, the hybrid outgrows the ponderosa in height also, at least until 11 years of age--the age of the oldest hybrids between those species. The 11-year data for the hybrid and its ponderosa pine check are:

	Height (feet)	D.b.h. (inches)
Hybrid	13	3.6
Ponderosa pine	10	2.7

For a field test, this hybrid was planted as 1-1 stock at Tony Gulch (elevation 4,800 feet) on the Eldorado National Forest in 1952. The hybrid transplants are performing well, but the ponderosa pine planting stock was in poor condition and nearly all have died. Consequently no statistics on relative vigor are available.

The Jeffrey-Coulter backcross hybrid, Jeffrey pine x (Jeffrey pine x Coulter pine), has outgrown Jeffrey pine at Placerville throughout 15 years--the age of the oldest of these hybrids. The hybrids average 22.4 feet tall and 6.1 inches in diameter; the Jeffrey pine, 13.5 feet and 3.2 inches. At Tony Gulch, 6-year-old trees of this hybrid are ahead of interplanted Jeffrey pines by about 25 percent.

Another 15-year-old hybrid, lodgepole pine x jack pine, has maintained its superiority in growth rate over its lodgepole pine checks from the outset at Placerville. It is now 15.8 feet tall and 3.9 inches in diameter, whereas the lodgepole pines of the same age average 9.1 feet and 2.1 inches.

The first hybrid produced at the Institute of Forest Genetics is a cross between knobcone pine and Monterey pine. Now 27 years old and about 70 feet tall, this hybrid has maintained superiority in growth rate over knobcone pines, now about 55 feet in height, from the outset.

Finally, the case of the Dunkeld larch, which is a cross between European larch and Japanese larch, is reported by several observers to be more vigorous than its parental species, surpassing them by a substantial margin from the seedling stage to at least 15 years of age.

Thus, lines of evidence from different kinds and ages of coniferous hybrids point to the conclusion that in many cases the original superiority of a hybrid over one or both of its parents will be maintained. Nevertheless, the Station regards the incompletely tested hybrids as suspicious characters. We are not yet ready to bond any of them, but we do recommend the more outstanding crosses for use provided they are interplanted with the parental species native to the region in which the planting site is located.

NEW BREEDING TESTS AND FIELD EXPERIMENTS

One of the largest artificial pollination programs ever undertaken by the Station was carried out in 1955. Altogether, 1,730 pollination bags were used--360 of them on 22 pine species or hybrids which were dusted with pollen of 28 species or hybrids. The remaining 1,370 bags were used in mass-production tests, 786 on ponderosa pine and 584 on Jeffrey pine. The purpose of the latter tests is to obtain data bearing on the economic feasibility of mass-producing promising hybrids through hand pollinations.

New field tests of hybrids were established at elevation 4,800 feet near Eleven Pines in cooperation with the Eldorado National Forest and at Pine Hill, elevation 1,800 feet near Placerville in cooperation with the State Division of Forestry. Both 1-0 and 2-0 stocks were used on the Pine Hill area, which is a dry, rugged site. The 1-0 stocks grown at the Institute of Forest Genetics survived much better than the 2-0 stocks, also grown at the Institute. The survival percents were 75.6 and 49.2 respectively. A 100-percent survival count was made of the 2,815 Institute seedlings planted at Eleven Pines. In this planting, 14 different pedigrees, including 8 different hybrids, were used. Total survival was 86.8 percent. All but 585 Jeffrey pines were 1-0 stocks. Survival of the 2-0 Jeffrey pines was 76 percent. Survival of Apache pine seedlings was 100 percent.

STUDY OF TURPENTINE CHEMISTRY COMPLETED

The comprehensive study of the chemistry of pine turpentines, which has been supported for the past 4 years by three successive grants by the Rockefeller Foundation to Dr. N. T. Mirov, will close officially on June 30, 1956 although there will be little laboratory work after February 1. The results of this investigation, however, will doubtless grow in importance with the passage of time and it may well be expected that many unforeseen uses of the results will develop.

Turpentines of 14 pines were processed during the year. Nearing completion are analyses of ponderosa pine oleoresins collected from 5 sections of the species range: Nebraska, Wyoming, southern Idaho, Colorado, and Montana.

BASIC RESEARCH PROJECT STUDIES PINE FLOWERING

Early in the year Resources for the Future, Inc. made a grant of $35,700 to Dr. Mirov for a 5-year study of flowering in pines. This new comprehensive investigation, following on the heels of the turpentine study, attests our reliance on basic research as the most

effective means of progress. The practical objectives of our genetics research are improved pines, and progress toward them is conditioned in part by reproductive characteristics of pines. These characteristics, at least their physiological and biochemical aspects, are not at all well understood. The objective of the investigation is to develop knowledge that will make it possible to control flower production much more readily than it can be done now. Ability to induce or prevent flowering would be of inestimable value in forest genetics research and tree breeding.

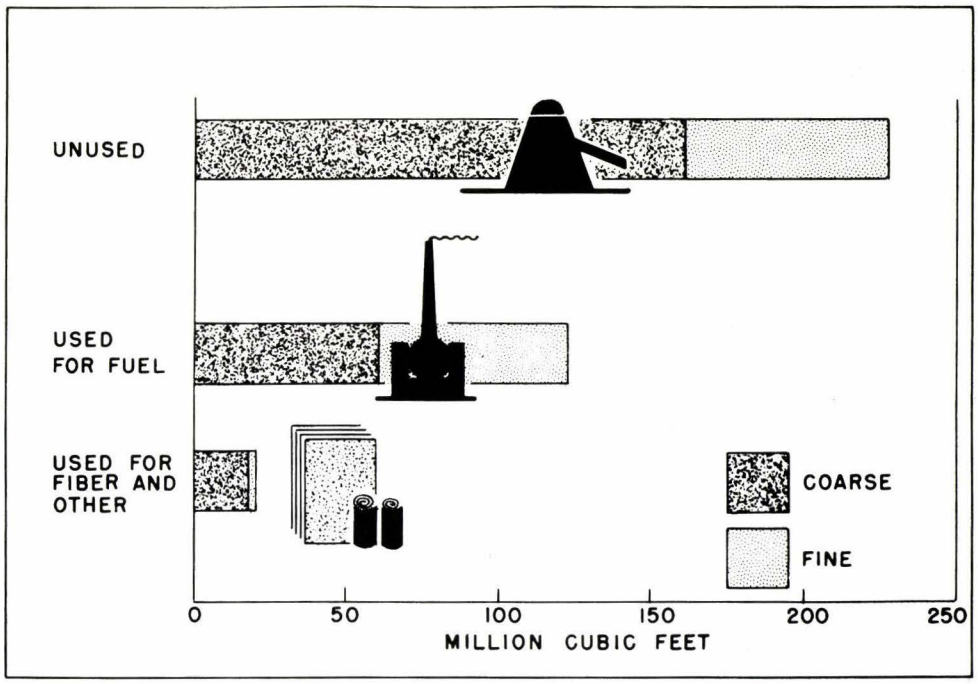
Work on the project got under way officially on July 1 with the start of various biochemical and physiological studies and some preliminary work on photoperiodicity. Dr. Robert Stanley, who is on a National Research Fellowship until July 1, 1956 is working with Dr. Mirov on this investigation. As the study progresses, the aid of other specialists will be enlisted.

FOREST UTILIZATION SERVICE

RESIDUES AVAILABLE FOR PULP AND PAPER INDUSTRY

Manufacturers of pulp and fiber products are shifting more and more to plant residues instead of logs for their raw material. More sawmills have installed slab chippers and several more log barkers are in use at sawmills. Barkers make possible the production of a larger volume of bark-free chips having a higher unit value, thereby giving a greater overall return to the mill. As they come into use, more and more mills will probably have to install barkers to produce the quality of chips demanded by the market.

Last year we mentioned the large volume of unused plant residues developed at primary manufacturing plants in the State. A report was recently published covering a survey of manufacturing wood residues made as a part of the Timber Resource Review. It showed that in 1952 more than 160 million cubic feet of solid wood residues were accumulated and sent to the burner for lack of economic use. This represented about two-thirds of the total of 243 million cubic feet of solid residues produced. The remaining third, or about 80 million cubic feet, was used as fuel for power production and heating purposes, for fiber, and for byproducts such as lath, shade rollers, and toy stock.



Wood residues used and unused in California.

In addition, 129 million cubic feet of fine residues (sawdust and shavings) were produced. About one-half of this was used for fuel, and a small part was sold for use as livestock and poultry bedding and for soil conditioning. The other half was unused and disposed of in the burner.

The slabs, edgings, veneer cores, and other coarse material making up the solid residues suitable for fiber use are so concentrated in several areas that a substantial percentage should be economically available. The quantity of material available is sufficient to support several additional fiber operations in the State. Judging from the number of inquiries about such material and studies being made by pulp industry organizations, its use for pulping should increase.

USES STUDIED FOR "NEGLECTED" SPECIES

Use of local hardwoods is developing slowly, but several companies are taking definite steps to determine their economic and commercial possibilities. Two veneer plants, one operating a slicer and one a lathe, have been built to operate on hardwoods. One plywood plant specializes in hardwoods and is making hardwood veneer into flooring. Further trials of hardwood veneer and black oak lumber production are under way.

To improve the utilization of little-used species, or to extend the utilization of important commercial species, we have furnished test material to the U. S. Forest Products Laboratory in Madison, Wisconsin, for studies of the properties of the wood. Included were shipments of Coulter pine, second-growth redwood, old-growth redwood (containing both heartwood and sapwood), valley white oak, and air-dried lumber of ponderosa pine and white fir.

No figures on the strength and related properties of Coulter pine had been available, although some lumber is now manufactured in the southern part of the State. The redwood was furnished for studies of wood preservation. Standard strength tests are being made on valley white oak, for which there are no figures at present. The ponderosa pine and white fir lumber was sent for studies of the nailing of these woods for containers.

The Forest Products Laboratory also has studied certain of the properties of white alder furnished by the Angeles National Forest. The results showed it to be similar to red alder in density, shrinkage characteristics, and other properties. Red alder is well established in the West Coast furniture industry. It is purchased as lumber and dimension stock and used for a variety of furniture items where its stability and ease of working make it quite acceptable.

Results of drying studies on black oak made in 1949 and 1950 in cooperation with two companies in the Pine Region were very encouraging. They showed black oak can be dried readily by conventional drying techniques, but neither of these two companies were in a position to continue product development at the time the seasoning studies were completed. Both companies are now ready to consider further the possibilities of sawing black oak and both are working toward some form of utilization.

In the Redwood Region operators are also working on the utilization of madrone, chinkapin, tanoak, and laurel. Madrone and tanoak squares that were turned into handles, knobs, dowels, and similar representative items at commercial turners in New Hampshire and California showed these woods to be suitable for this use. The madrone was found to turn exceptionally well. Because madrone and tanoak are difficult to dry in the form of lumber, especially as wide flat-sawed boards, utilization as turning squares appears to have advantages.

Studies at the Forest Products Laboratory, to determine how best to slice and peel California hardwoods, showed these woods can be made into veneer and plywood with no special problems.

DRIVE CONTINUES FOR IMPROVED LUMBER SEASONING

We have continued to work with the groups of dry kiln operators interested in seasoning research and application of new and improved drying methods. During 1955, the 3 clubs wholly within the State held a total of 21 meetings that drew an attendance of more than 650 men.

Dry kiln clubs, or lumber seasoning associations as some are called, continue to be an effective means for getting information on new and improved drying techniques to kiln operators. This is accomplished by participation at club meetings and by furnishing published papers to the members. During the year 17 different reports were sent to 330 men throughout the State.

The Redwood Seasoning Committee provides an excellent example of what can be accomplished by group action. This committee celebrated 10 years of active research and application of seasoning research at its 100th meeting early this year. It enjoys unusually fine guidance through the California Redwood Association and exceptional backing from management. The committee was originally organized to guide the kiln-drying studies carried on by two full-time engineers. This work, which is now carried on by kiln operators and other interested personnel, has resulted in valuable information and operating procedures for air-drying, use of lumber end-sealers for air-drying and kiln-drying, use of lumber predriers, and the application of quality control to lumber drying.

SEASONING METHODS STUDIED FOR INCENSE-CEDAR PLANKS

Seasoning incense-cedar in the form of 3-inch planks or squares is important to the better utilization of this species, which is one of the most widely distributed secondary species in the State. It comprises only a small part of the total timber stand of the Pine Region of California but adds appreciably to the value of the timber harvest when it is logged. Virtually the total annual cut of 80,000,000 board-feet is manufactured into 3-inch planks or squares which are later remanufactured into pencil slats. One problem in manufacturing is to dry the rough planks or squares to a moisture content of 12 to 18 percent without objectionable degrade in less time than is now required by air drying.

To help develop a practical commercial drying procedure, we made a seasoning study in cooperation with the California Cedar Products Company, Stockton. The study included kiln-drying stock green from the saw, air-drying, and a combination of air-drying followed by kiln-drying.

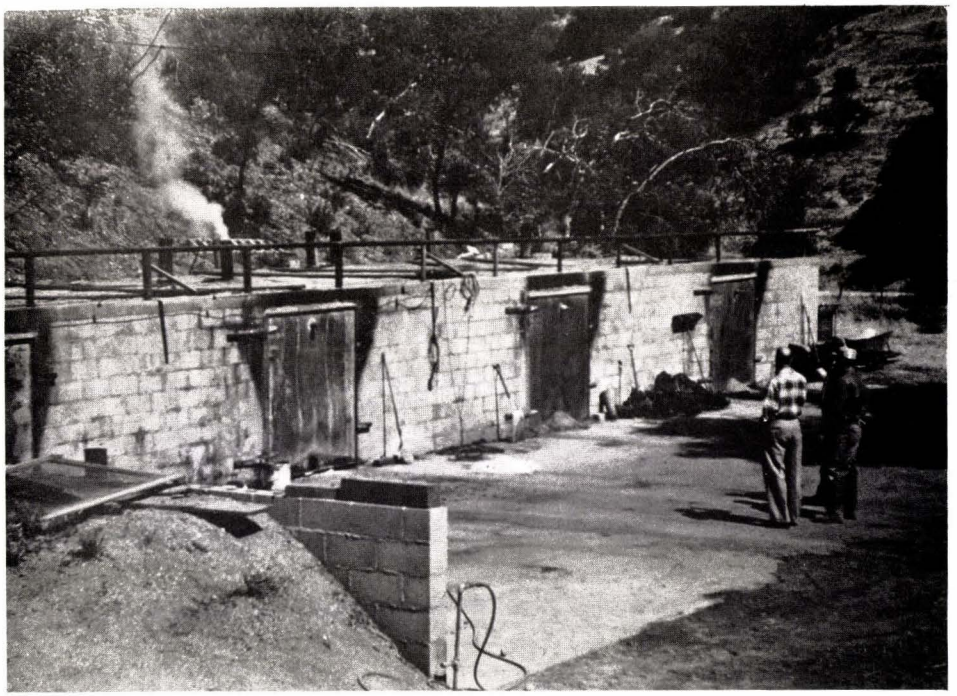
This work showed that the sapwood and light heartwood can be kiln-dried readily, even when green. The sinker-type heartwood, however, is slow to dry and prone to degrade during kiln-drying. The sinker-type must be segregated if freshly sawed lumber is to be kiln-dried without first being air-dried. Segregation is difficult because sapwood and sinker-type heartwood are contiguous or closely associated in the standing tree and because streaks of the sinker-type wood may extend through otherwise easily dried light stock.

The logical procedure appears to be air-drying followed by kiln-drying to the desired final moisture content for manufacture into pencil slats.

Squares air-dried faster and with significantly less checking than planks. The spacing between lumber piles had little influence on drying rate during the severe drying weather of the summer months, but may have a significant influence on drying rate during the slower drying weather of the winter months.

CHARCOAL PRODUCTION AIDED BY NEW KILNS

For many years charcoal has been produced in the State on a small scale and in rather primitive types of kilns. In recent years the demand for charcoal has increased, mainly because of the growing interest in outdoor cooking, barbecuing, and camping. During the past year we have been consulted by and have advised several people on types of kilns, processing, and related problems. Several improved types of kilns have been built recently and are being operated on a more systematic and efficient basis. Apparently, the market is continuing to expand, and more installations may be set up. Practically all the production in California is in the Paso Robles and Healdsburg areas. The wood used is chiefly liveoak with small proportions of associated hardwoods. There is some charcoal production in the foothill area of the Sierra Nevada using oak, but production there is still rather small.



An example of the types of charcoal kilns being built in California.

WOOD PRESERVATION STUDIED FOR YOUNG-GROWTH REDWOOD

Looking forward to the use of young-growth redwood for poles, we arranged for experimental treatment of such material at the Forest Products Laboratory 2 years ago. Recently material for additional tests was sent to the laboratory through the cooperation of the California Redwood Association. Purpose of this work is to get further information on the penetration of preservatives used in pressure processes and to study the adaptability of redwood to the double diffusion method of treating.

The double diffusion process is a simple, non-pressure treatment which requires only relatively inexpensive equipment. The material to be treated is first soaked in a water solution of copper sulfate, then in a water solution of sodium chromate. The two chemicals diffuse into the wood and then combine to form an almost insoluble toxic compound that protects the wood from decay and insects.

The process is suited to the treatment of round, unseasoned posts and poles. It is quite flexible and can operate on a small scale. If the results of this work are satisfactory, it may make possible the utilization of considerable volumes of young redwood trees which should be removed from the timber stand as a silvicultural improvement measure.

FOREIGN WOODS FIND USES IN LOCAL TRADE

Foreign woods imported into California continue to supplement the production of domestic species to an extent. Philippine woods, mostly the white and red lauans, are now coming from Japan, where the logs are imported for manufacture into lumber and shipped to the world trade. Several other species besides the lauans are also imported, notably some in the apitong group.

Some Philippine logs have also been imported and manufactured into lumber in California mills on an experimental basis. At least one California veneer plant is slicing imported hardwood cants.

Lumber is also imported from Mexico and Central and South America. Several California lumber interests are investigating the possibilities of establishing sawmills and other wood-using plants in Mexico and Chile. The Mexican ponderosa pine is the principal species there, while alerce and coigue are the species of Chile about which we have been consulted. The Forest Products Laboratory, Madison, furnished figures for strength and related properties for alerce and coigue. The figures thus obtained showed alerce, a conifer, to be very similar to old-growth California redwood. Coigue, a species of Nothofagus, is one of the most widely distributed hardwoods of Chile. It resembles sweetgum, although somewhat heavier. It has a variety of uses in Chile such as in construction, flooring veneer, and boxes.

FOREST FIRE RESEARCH

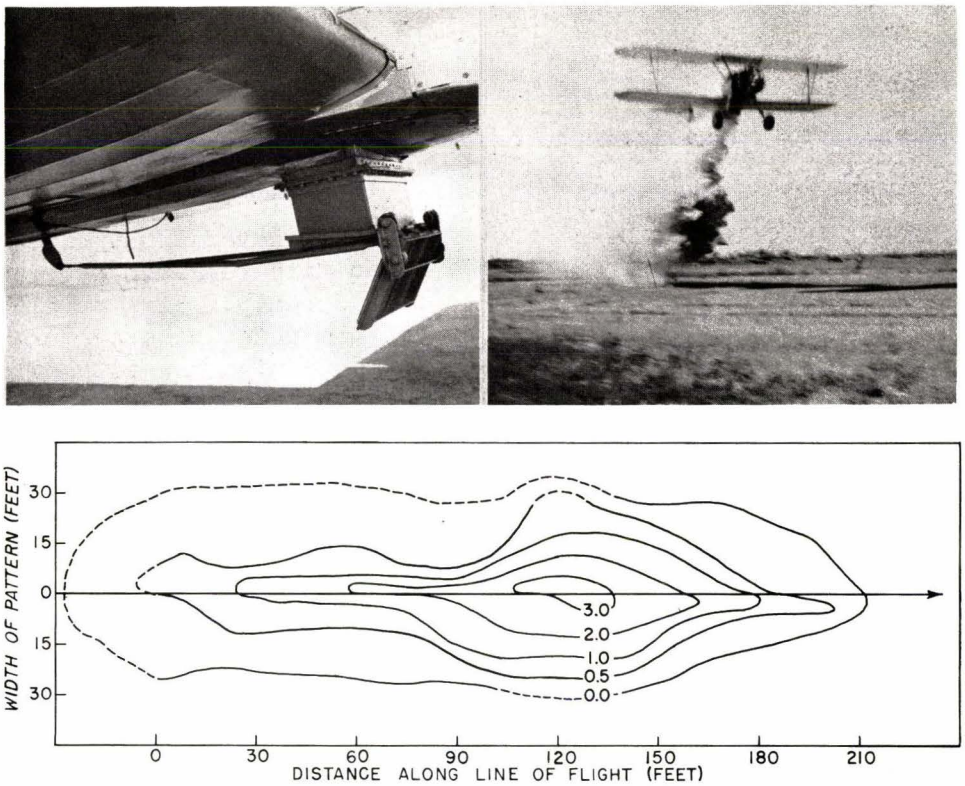
FIRE RESEARCH REORGANIZED

California's disastrous fire season last year emphasized the need for more intensive fire research. Although little immediate intensification could be accomplished during the year, fire research was reorganized and several new cooperative projects started. Three broad fire research programs are now underway under competent leadership. Fire physics studies are designed to ferret out the principles of combustion. Fire environment studies determine how to predict behavior of wind and other factors of the forest environment that affect fire behavior and their interaction with fire. Fire-control studies adapt the findings of fire physics and environment to practical control applications and through cooperative operations research seek to improve all fire-control operations.

AIR DELIVERY OF WATER HELPS CONTROL FIRES

Special adaptation of aircraft to various phases of forest fire fighting is expanding rapidly. Their versatility in delivery of water was revealed in tests conducted by cooperators and the Station fire research staff. Early in the 1955 fire season, the Mendocino National Forest and the Willows Flying Service found that water could be dumped from a small airplane in one giant splash with significant effects on small grass and brush fires. The key to success was a special quick-opening outlet for the water tank carried by the plane. The technique looked promising, but quantitative information was needed to improve tactical methods for air delivery of water.

In August the Station staff, in cooperation with Mendocino National Forest, Willows Flying Service, California Division of Forestry, and Arcadia Equipment Development Center, conducted tests to measure the effects of plane height and speed and of wind velocity and direction on the amount and distribution of water received on the ground. The practicability of dropping solutions of fire-retardant chemicals from the aircraft was also tested.



Small airplane equipped with special tank outlet, top left, can be an effective aerial tanker. Test drop at top right was made with fire-retardant solution. At bottom is distribution pattern of one test, showing concentration of water in gallons per 100 sq.ft.

The best results were obtained when the flight was made into the wind at the low altitude of 30 feet and a low air speed of 80 miles an hour. Under these conditions 75 percent of the 125 gallons of water in the tank reached the ground. This flight also resulted in the highest concentration of water at one point. Cross wind flights of higher altitudes and greater air speed tended to disperse the water over a longer and wider area, which would decrease the effectiveness of the water on a small hot fire. The retardant, being heavier than water, did not disperse as readily as water and therefore penetrated the brush more uniformly. Particularly needed is more information on the amount of water or chemical required to affect fires under different burning conditions.

The aerial tanker looks like a good firefighting tool, but few guidelines on the best ways to use it can be given until more operational tests are made. However, we can conclude that aerial tankers equipped with special tanks and release levers similar to those used in these tests will be useful for checking spread of fire temporarily until ground crews arrive. Pilots should be experienced in flying under mountain conditions and cautioned to watch for sudden jumps of the airplane when releasing large amounts of water.

CHEMICAL FIRE RETARDANTS PROMISE BETTER CONTROL

Operational tests during the year showed that solutions of fire-retarding chemicals have at least one distinct advantage over water alone. They extend the length of time that fuels will remain fireproofed ahead of a fire. When used directly on the fire, however, retardants have little superiority over water.

Solutions of sodium-calcium borate were tested in three situations: Direct attach on 1,500 feet of fire in light brush and grass, pretreatment of brush and grass on 7,400 feet of fire line, and treatment of 400 feet of backfire line in brush and grass. These tests demonstrated that fire-retardant chemicals should increase the striking power of small crews. Sprayed in advance of the fire (pretreatment), chemical fire lines held the flanks, rear, and slower spreading parts of the head of fires in light and medium brush and in grass. Continued operational tests seem advisable until more is learned of what the chemicals will and will not do and how they should be used. Better mixing and applicating equipment must also be developed before chemical fire retardants can have wide application.

FIRE PREVENTION STUDIES STARTED

A 2-year fire-prevention research project was started in cooperation with California Region of the Forest Service this year. Its specific objective is to develop measures for evaluating the results of a variety of fire-prevention activities. Some of the questions the new project will attempt to answer are: What kinds of prevention activity are most effective in reducing numbers of fires? To what extent are fewer fires a result of weather, fuel changes, forest-use changes, or prevention programs? What are the related prevention jobs on different forest areas?

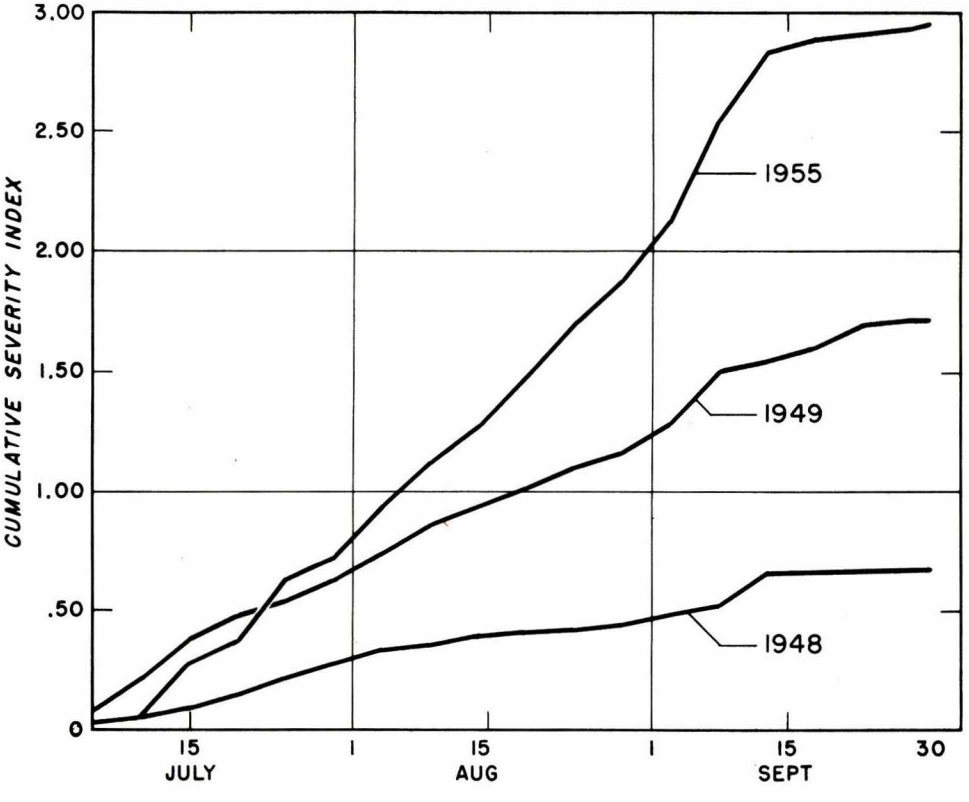
As a beginning, a pilot study was made of the way severity of fire weather and use of the forest affect the number of man-caused fires on lands protected by the Forest Service in northern California. When these factors were

not taken into account no definite trend in number of fires was evident between 1945 and 1954. When their effects were considered, a downward trend in numbers of fires could be seen for the 10-year period. The next step will be to find a way to appraise the significance of this trend in terms of effectiveness of prevention effort.

UNIFORM FIRE-DANGER RATING NEEDED FOR CALIFORNIA

A cooperative study of fire-danger rating was begun during the year by the Station, the California Division of Forestry, and the U. S. Weather Bureau. It will eventually provide a much needed uniform system of fire-danger rating to replace the several systems now in use by different fire agencies in the State.

In one phase of this work 64 weather stations now in use on the Sequoia, Mendocino, Six Rivers, Shasta-Trinity, Modoc, and Cleveland National Forests were inspected during the year. Many station locations were revised, five new stations were added, and two of the old ones were dropped. It



Fire season severity index, cumulated by 5-day periods, Area 1, Klamath National Forest.

was found that when fire weather stations were not operating up to standard, they invariably recorded fire-danger ratings lower than they should have been.

In this inspection, we used as a guide the new handbook on weather station installations and inspections standards, "Fire Danger Stations and Instruments," which was prepared by the fire research division and released during the year as Part 4 of the Region Five Fire Handbook. More accurate measurement of the many variables involved in fire-danger rating, and more uniformity of the measuring instruments, should result in improvement of the present rating system.

The unprecedented 1955 fire season also emphasized the need for a current index of seasonal severity to supplement daily ratings. Post-mortem study of severity indexes for the Klamath National Forest showed striking differences in the cumulated severity for 1948, an easy fire year, for 1949, the most severe season before 1955, and for the 1955 season. Plotting a severity curve currently each year evidently is one way to keep track of the relative job load. When current and past seasons are compared, fire-control planning and strategy can be adjusted to take into account unusual conditions and potential for disastrous fires.

Table 2.--Fire season severity indexes for selected stations in California national forests

Year	Yreka (Klamath)	Adin (Modoc)	Quincy (Plumas)	Pinehurst (Sequoia)	Los Prietos (Los Padres)
1955	2.95	2.51	2.34	1.90	1.09
1954	1.10	1.07	1.27	1.24	0.94
1953	0.65	0.93	1.14	1.13	1.07
1952	0.76	1.76	1.01	1.00	0.76
1951	1.30	1.51	1.21	-	1.74
1950	1.32	1.13	0.94	1.73	1.48
1949	1.72	1.09	1.74	1.73	1.27
1948	0.67	0.75	0.23	0.74	2.68
1947	1.35	1.51	0.92	1.39	1.42
1946	0.70	1.97	1.36	1.30	1.70
1945	-	1.71	1.37	1.25	1.73

Severity ratings for selected national-forest stations (table 2) show the extreme burning conditions of the 1955 fire season. Although the indexes cannot be compared between forests, because each year at each station is related to its own average weather, the 1955 ratings were the highest recorded since 1945 at all stations except Los Prietos on the Los Padres National Forest. A burned area of more than 100,000 acres in 1955 in northern California compared with less than 16,000 acres in 1948 bears out the significance of the severity ratings in evaluating fire danger.

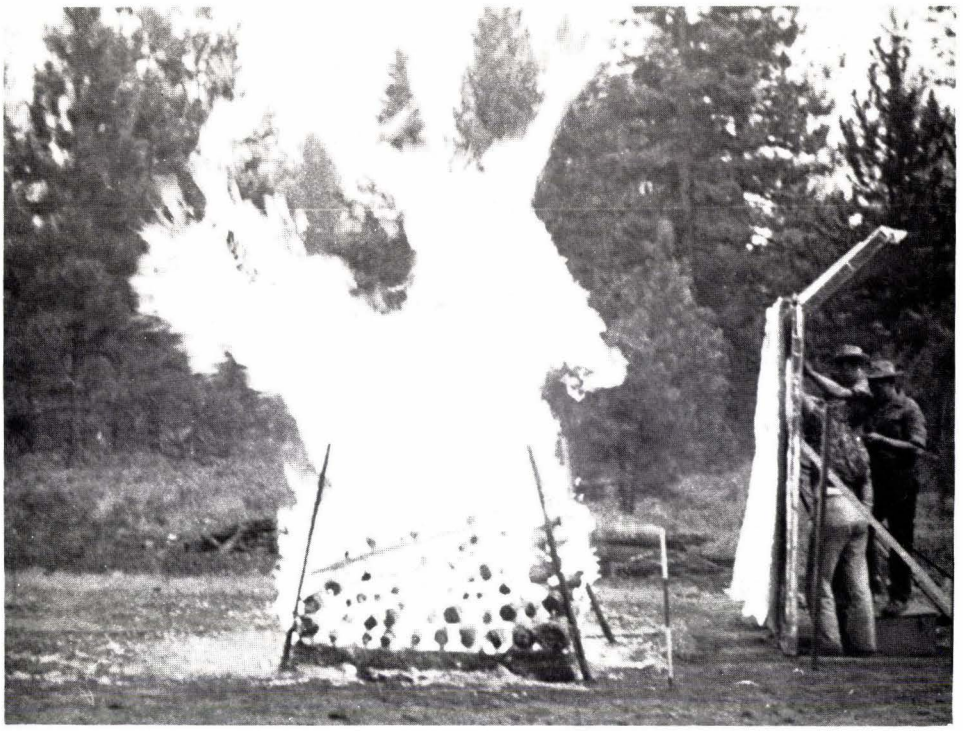
NEW LABORATORY FACILITIES AID FIRE PHYSICS RESEARCH

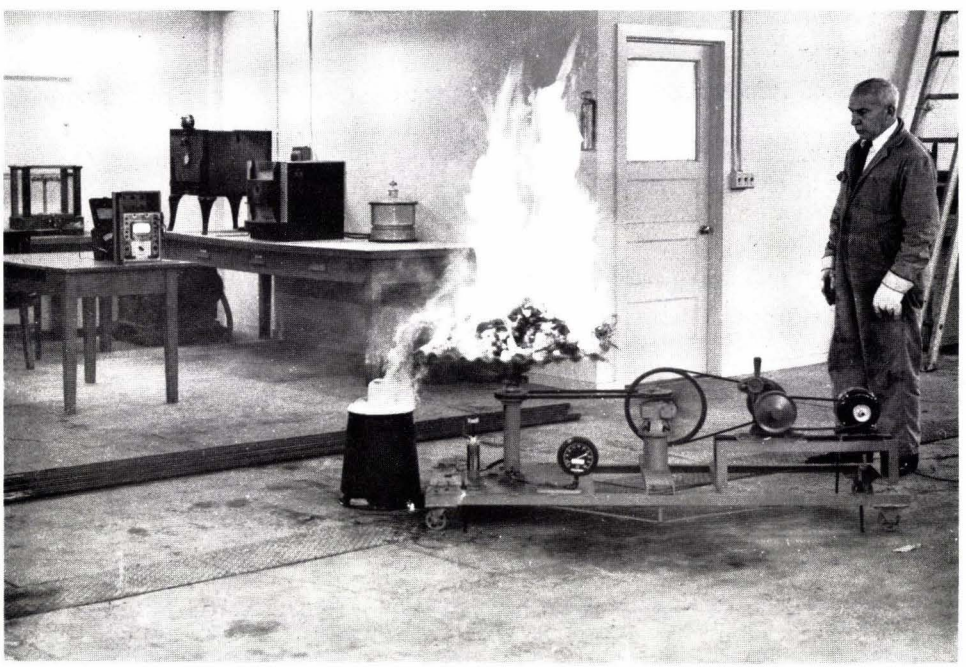
In the final analysis, an accelerated flow of new information for fire control depends on basic research that yields precise quantitative knowledge of the elements known to affect fire. New facilities for work of this kind were developed in laboratory space provided by the University of California Department of Engineering. A 1,600-square-foot room at the Engineering Field Station in Richmond has been equipped for model-scaled studies. Its 30-foot ceiling makes this laboratory ideal for burning scaled and controlled model fires to study forest fire ignition, combustion, and other basic factors.

Field-scale tests this year provided some new knowledge of the flame characteristics of wood fires. These tests were conducted at the Station's Pilgrim Creek branch near Mt. Shasta. One phase of the tests was measurement of radiant heat output from model fires. It was found that the radiant heat impinging on an object 6 feet from one of these fires is equivalent to 80 suns. Most of this radiant heat is in the infra-red region of the spectrum, less than 1 percent is from the flame in the visible region.

OPERATION FIRESTOP DRAWS TO A CLOSE

The work of Operation Firestop moved into its final phase this year with the production of a 25-minute documentary motion picture and the publication of 7 of the 12 remaining reports of Firestop activities. The movie was filmed during the operation at Camp Pendleton Marine Base in 1954. It shows how tests were conducted there and includes spectacular shots of 600-gallon water drops from a TBM bomber and of helicopters pulling hose from a tank truck. Time-lapse pictures show development of smoke columns and fire behavior. Many other phases of the project are filmed to show the cooperative contributions of industries and federal, state, and county agencies.





Model fires at Pilgrim Creek field research station, top, and at new fire laboratory provide knowledge of fire physics.

WEATHER COURSE DEVELOPED FOR FIRE FIGHTERS

A course in fire weather and behavior was given to fire-control officers by Station and Weather Bureau personnel. The course explains how such elements of fire weather as air temperature, humidity, wind movement, heat transfer, and moisture content of fuels are related to fire behavior. It also discusses how these relations are influenced by conditions in the field such as topography and seasonal trends. The course will be further developed for use in fire-control training.

Another training aid developed during the year is a motion picture for instructors showing some of the ways key points concerning the conservative and effective use of water on forest fire can be demonstrated by a training team. The action was filmed and the narration for the sound track prepared this year. The finished movie will be available for showing early in 1956.

FOREST INSECT RESEARCH

INSECTS CONTINUE TO DEPLETE FOREST RESOURCES

California forest resources in 1955 continued to provide food and shelter for an unnecessarily large number of destructive insects. It is estimated that the quantity of timber killed or injured by insect pests exceeded 1.5 billion board-feet. This is equivalent to about one-half the net annual growth and about one-quarter of the timber cut in the State. The over-all level of insect-caused damage in 1955 was about the same as that in the past 3 years. Despite the magnitude of the losses, damage was low by comparison with the midthirties. The fact that losses are not higher than they are can be credited, to a considerable extent, to better forest management and to improvement in the efficiency of insect-control practices.

Although the losses did not change greatly, surveys conducted by the Station revealed that changes did occur in the activities of many pests that contribute to the total loss. Some infestations decreased. In northwestern California, the Douglas-fir beetle, in outbreak over 200,000 acres since 1953, declined sharply. In the Sierra Nevada, an epidemic of the white-fir sawfly which began to decline a year ago continued to decrease in 1955. Sporadic outbreaks of the fir engraver occurred throughout the white fir and red fir belt in the northern part of the State, but

damage generally was normal. The spruce budworm, a pest of great potential destructiveness, became very scarce in 1955. The budworm has persisted for many years in the North Warner Mountains of California without causing serious damage.

These favorable developments were offset by increases in the depredations of other insects. The lodgepole needle miner infestation in Yosemite National Park was the most extensive single insect outbreak in the State for the third consecutive year. The needle miner severely defoliated 45,000 acres of old-growth lodgepole pine in the Park. Another 3,000 acres in Sequoia-Kings Canyon National Park were damaged. The outbreak showed no signs of abating. Efforts to control it with DDT sprays have not been successful, but studies conducted this year indicate that malathion insecticides may be effective against this insect.

The Yosemite outbreak is complicated by a rapidly developing infestation of the mountain pine beetle in trees weakened by needle miner defoliation. The mountain pine beetle is epidemic on 5,400 acres and, in the wake of the needle miner, has killed nearly 50 percent of the stand in this area in the past 4 years.

For the first time in several years, signs of an upswing in the activities of other pine bark beetles were discovered in northern California. Pine engravers, the western pine beetle, and the Jeffrey pine beetle were the principal insects. The tussock moth, a pest of white fir, seriously defoliated white fir stands on 5,000 acres in the central Sierra Nevadas. Cone and seed insects exacted a heavy toll of an already scanty seed crop in Douglas-fir and sugar pine.

The outlook for insect damage during the next year or two is not very favorable. Serious fires in 1955 have left an abundance of injured timber that is likely to favor large populations of bark beetles. Salvage operations will eventually remove most of the dead and weakened trees; but, unless the weakened trees can be cut before beetles begin to breed in them, serious infestations are likely to build up that will spread into the surrounding stand.

Early detection and prompt suppression of insect outbreaks are one means by which losses may be reduced. To this end, the Station has continued to spearhead the cooperative forest insect detection survey. We have coordinated reports of insect damage from foresters throughout the State and have provided entomological advice and followup as needed. In cooperation with the California State

Division of Forestry and other land managing agencies we conducted ground and aerial surveys of critical infestation areas. We have trained forest officers on several national forests on how to detect insect damage and how to recognize the principal insect pests. In addition, our entomologists have assisted the University of California in training foresters in State and private industry.

HELICOPTER TESTED FOR BARK BEETLE SURVEYS

Helicopters can be used to good advantage in obtaining estimates of bark-beetle damage in remote forest areas. This conclusion is based on the results of trial surveys of Douglas-fir beetle losses made by the Station last spring in northwestern California. The California Division of Forestry and the administrative branch of the Forest Service cooperated in the tests.

Aerial methods of making forest insect surveys have been used by the Station with increasing frequency since World War II. For most such surveys in California, airplanes have proven satisfactory; consequently, helicopters have not been tried. We know though, that for certain types of work airplanes are of little value. For example, when we need to make an accurate count of insect-killed trees and pinpoint their location, airplanes cannot be flown slowly enough and, in rough terrain, low enough to obtain the necessary information. Moreover, airplanes usually must be operated from an improved landing field--a facility that is not always available. For such surveys, helicopters have obvious advantages.

To determine the reliability of estimates obtained with a helicopter, insect-killed trees were counted from the air and from the ground. The site of these tests was a 2,000-acre area of old-growth Douglas-fir in a remote part of the Six Rivers National Forest. This area was chosen because it had sustained considerable damage in a recent Douglas-fir beetle outbreak. The dead trees were counted and classified either as newly killed (if they had fading foliage) or older dead. The number of trees in each of these categories, according to the method by which they were counted, was as follows:

	Newly killed	Older dead	Total
Ground survey	49	180	229
Helicopter survey	45	143	188

The estimates obtained from the air underran those from the ground by 18 percent. By combining aerial operations with enough groundwork to establish the average size of the dead trees, estimates of volume killed may be obtained. For practical purposes, helicopter surveys of bark-beetle damage can probably be relied upon to produce estimates that are about 80 percent of the actual losses.

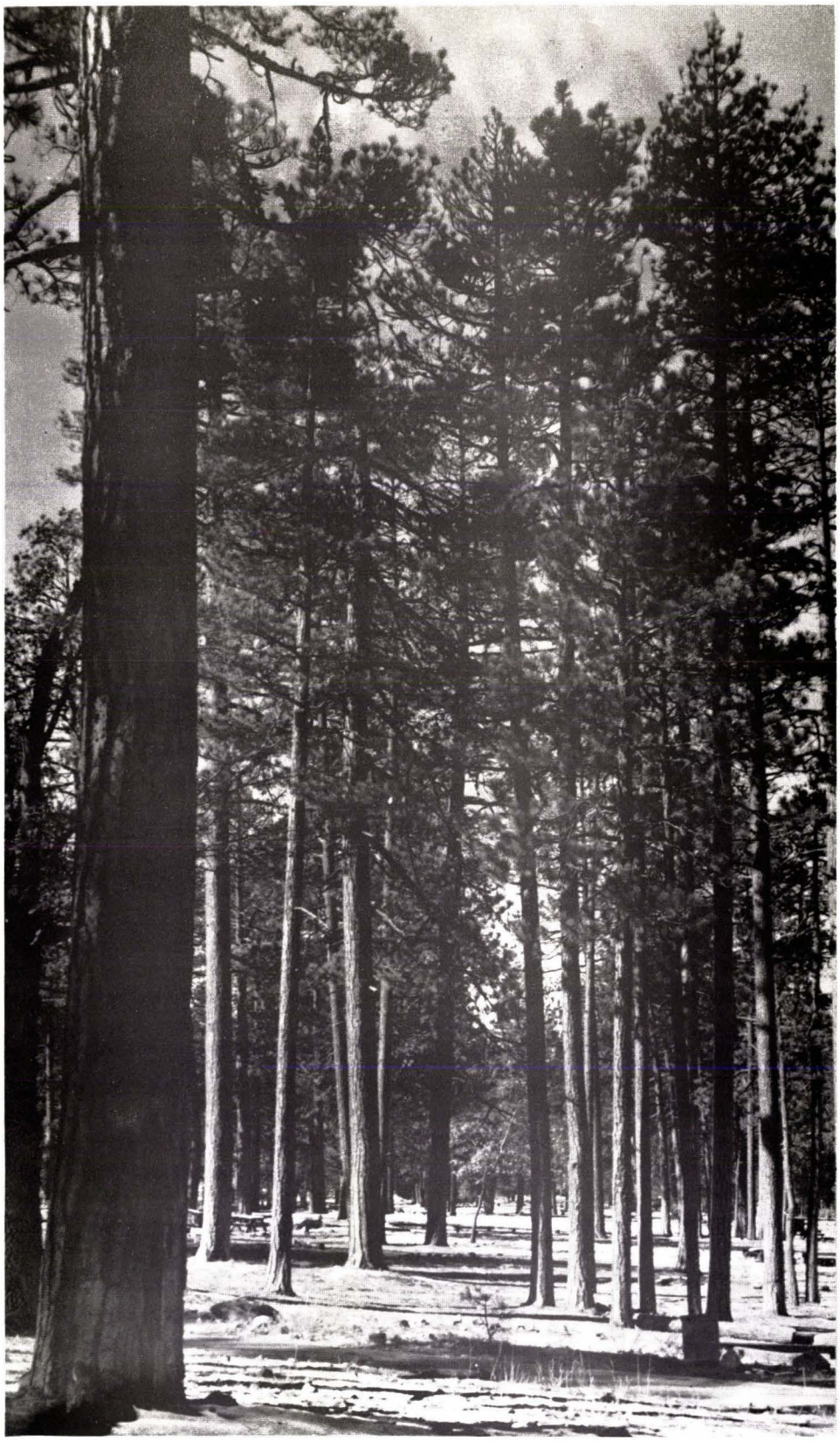
The cost of chartering a helicopter--$95 per hour in this test--prevents them from being more generally used in forest insect surveys. But where lack of access, rough terrain, or urgency of the situation are factors to be considered, the helicopter may be the most efficient way of obtaining damage estimates.

SANITATION SALVAGE CONTROLS BEETLES IN RECREATIONAL FORESTS

Recent investigations have shown that sanitation-salvage cuttings hold considerable promise for controlling beetles in the pine forests of southern California. Sanitation-salvage provides for curtailing insect losses through forest management. Weakened or decadent trees, called high-risk because they are especially susceptible to beetle attack, are logged before they become a breeding place for beetles which would then attack the healthy trees in the stand. The effectiveness of this method against bark beetles in the commercial pine forests of northeastern California has been well established by studies the Station has been conducting at Blacks Mountain Experimental Forest. Until recently, however, the value of sanitation-salvage as a beetle control measure in the southern part of the State was unknown, chiefly because there was no opportunity to test the method.

The forested areas of southern California, because of their scattered distribution, relatively small size, and scanty stocking, are not a major source of timber. They are highly prized, however, for recreational purposes and for watershed protection. Insect damage over the years, especially beetle damage in ponderosa and Jeffrey pine stands, has been severe. Intensive insect suppression campaigns have provided some relief, but they have not improved the ability of the forests to withstand the onslaught of beetle attacks.

To test the effectiveness of sanitation-salvage under southern California conditions, the Station cooperated with national forest administration in starting a trial of the method on the San Bernardino National Forest in 1953. A 5,500-acre area of mature and overmature



A year ago, trees that would fall easy prey to bark beetles were logged in this recreation area. Losses were cut 95 percent, and the forest is in healthier condition to resist insects.

ponderosa and Jeffrey pine at Barton Flats--a section of the Forest extensively used by campers and recreationists--was chosen as the site for the test. Cutting of beetle-susceptible trees was started in September 1953 and completed in November 1954.

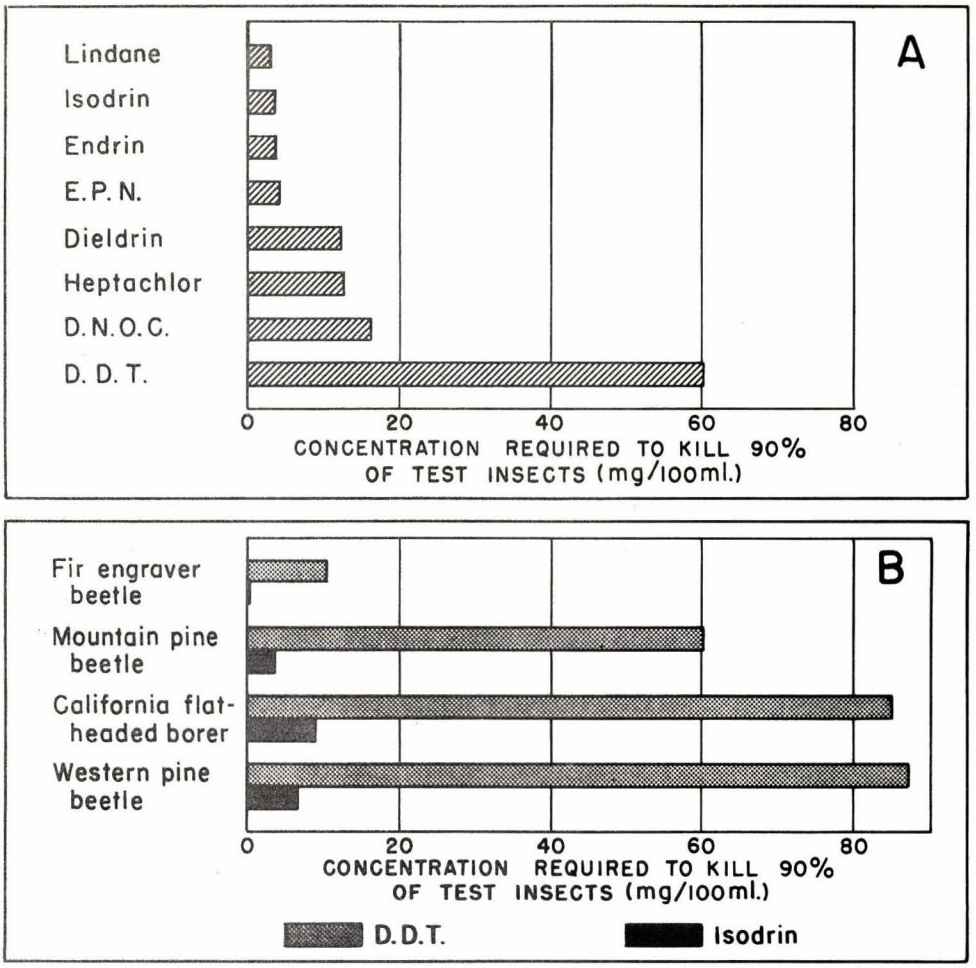
Before cutting, annual losses due to the western pine beetle, Jeffrey pine beetle, and California flat-headed borer exceeded 200 board-feet per acre--the equivalent of 1.5 percent of the total stand each year and a highly epidemic condition. In the year since sanitation-salvage was completed, losses were less than 10 board-feet per acre, a 95 percent reduction. This reduction compares favorably with that obtained by sanitation-salvage cuttings in commercial stands in the northeastern part of the State.

RESIDUAL-TYPE SPRAYS SHOW PROMISE FOR CONTROLLING BARK BEETLES

Better tools for destroying tree-killing bark beetles may soon be available as a result of research now being conducted by the Station. Since bark beetles are the most destructive insect pests in California, the quest for better ways to control them occupies an important place in our research program. Recent studies indicate that residual-type sprays promise more effective, lower-cost control.

These sprays are insecticides that form a lasting deposit, toxic to insects, on the surface to which they are applied. Their ability to remain toxic over a period of time is called residual life. An insect alighting upon or walking over a spray deposit during its residual life will pick up a lethal dose. When an insecticide with a long residual life is sprayed on the bark of an infested tree, it will kill beetles coming out. Sprayed on a healthy tree, it will kill insects attempting to attack through the bark. Thus, residual sprays offer possibilities not only for controlling existing beetle infestations but for preventing new attacks.

Research to date has been directed toward answering the first essential question: Which residual compounds are most toxic to the more important bark beetle species? To answer this question hundreds of beetles have been treated in a way that yields comparative figures for defining the relative toxicity of each compound tested. Results so far have shown that great differences in toxicity do exist between different compounds and different insect species. For example, in terms of the quantity of chemical required to kill 90 percent of the test insects, insecticides like lindane and isodrin proved many times more powerful than



Residual sprays differ widely in effectiveness: A, 8 compounds tested on mountain pine beetle; B, 2 compounds tested against 4 insect species.

DDT against the mountain pine beetle. Similar results were obtained in tests with the fir engraver, western pine beetle and California flatheaded borer.

All insect species are not equally susceptible to the same quantity of a particular insecticide. To illustrate, the results of tests with DDT and isodrin showed great differences in the toxicity of both these chemicals on four beetle species. Moreover, much smaller quantities of isodrin than DDT are necessary to produce the same degree of kill. The next step in this work will be to learn how the physical state of toxic deposits can be altered. The state of a deposit determines in large measure how readily an insect walking over it will pick up a quantity that will

kill. Better control, therefore, can be obtained with improved deposits.

NEW INSECTICIDES EFFECTIVE AGAINST LODGEPOLE NEEDLE MINER

Some hope of controlling the lodgepole needle miner is provided by the results of studies conducted by the Station in 1955. Currently in outbreak in Yosemite and Sequoia-Kings Canyon National Parks, the needle miner is a serious pest of long standing in the high Sierra lodgepole pine forests. It is also a menace to commercial timber stands adjacent to present infestation areas. In Yosemite, where it has been most destructive, the needle miner, aided by the mountain pine beetle, has periodically killed entire stands of lodgepole pine and left ghost forests of bleached snags. Intermittently over the past 50 years, forest entomologists have studied the needle miner with the object of finding an effective method of control. Previous research, however, has failed to produce practical control measures. Recent tests indicate that certain organic insecticides, notably malathion, may be effective for checking the damage.

In 1953, studies of the current needle miner outbreak were begun by Station entomologists in cooperation with the National Park Service. In these latest studies a great deal of attention has been given to natural factors that may curb outbreaks. We have learned that the needle miner has many natural enemies, chiefly insect parasites, predators, and diseases. However, so far none has been discovered that could be manipulated in such a way as to halt the outbreak. A large-scale test of DDT insecticide, in which 11,000 acres were sprayed by airplane, was not effective.

During the past year additional tests with insecticides have been made, using some of the newer chlorinated hydrocarbon compounds. The results of these studies show promising possibilities for controlling the needle miner. Chemicals tested were endrin, dieldrin, malathion, heptachlor, and DDT. Each was dissolved in diesel oil at the rate of 1 pound of chemical per gallon of oil, and sprayed on needle miner-infested lodgepole pine foliage with a hand sprayer. Tests were made against the following developmental stages of the insect: half-grown larvae, pupae, and adults. The percent control obtained in these tests was as follows:

Chemical:	Half-grown larvae	Pupae	Adults
Malathion	100	16	99
Endrin	99	10	10
Dieldrin	98	0	8
Heptachlor	Not tested	0	Not tested
DDT	51	14	Not tested
Diesel oil	Not tested	Not tested	0

Malathion was highly effective against the half-grown larvae and the adults. None of the chemicals was effective against the pupae. All in all, the results of these studies are promising, and the next phase of research will be to determine the proper dosage and method of application.

SEED CHALCIDS DESTROY LARGE PART OF DOUGLAS-FIR SEED CROP

That cone and seed insects are an important limiting factor in the regeneration of Douglas-fir is becoming well known. However, quantitative data have not been obtained in northwestern California until recently. This year research workers examined 7,500 Douglas-fir seeds caught in seed traps during 1954. They found that only 10 percent of the seed was sound. Seed chalcids destroyed 25 percent and 65 percent was destroyed by other insects or was unsound for other reasons.

It is reasonable to expect that insecticides may be effective in protecting the Douglas-fir seed crop. Studies elsewhere have shown that DDT sprays show promise for this purpose, but practical methods have not been developed. The Station, in cooperation with the administrative branch of the Forest Service, plans to test the use of aircraft for spraying Douglas-fir stands to prevent seed losses in 1956. Used successfully against such insects as forest defoliators, DDT spraying by aircraft costs about a dollar per acre. If this method of control is equally effective against cone and seed insects, substantial increases in the quantity of sound seed per acre could be expected at a comparatively small cost.

FOREST DISEASE RESEARCH

FOREST DISEASE SURVEY STARTED IN CALIFORNIA

The first survey of forest disease conditions throughout the State was started July 1. Limitations of time and funds curtailed this first season's work considerably, but plans were developed and the survey carried forward by means of detection reports from cooperators and field appraisals by Station pathologists. Probably the most alarming discoveries to come from the survey so far are the heavy and extensive damage from dwarfmistletoe, especially in red fir, and the serious damage from Elytroderma needle disease in ponderosa and Jeffrey pine.

Dwarfmistletoe is causing severe damage in many of the red fir stands throughout the Sierra Nevada. Heavy mortality of mature trees has occurred in some areas, especially in the southern Sierra. This parasite not only kills trees through multiple branch killing, but it also causes large bole cankers where trees may be weakened by decay and broken off by wind. Trees that are not killed in these heavily infected stands are badly suppressed and deformed, causing enormous losses in increment and quality of timber.

As a possible means of reducing dwarfmistletoe damage in red fir, Station pathologists recommended salvage logging and removal of infected overstory trees at many localities in the southern Sierra, and priority cutting of several infected stands in the northern Sierra. The mistletoe was also reported on ponderosa and Jeffrey pines in eastern Plumas County, southern Lassen County, and the Sequoia National Forest. For these places, pathologists recommended experimental control through pruning and removal of infected material.

The Elytroderma needle disease was found to be causing far more damage in California than previously believed. Ponderosa and Jeffrey pine stands have suffered notable mortality and considerable decline in many localities throughout the State. Mortality and decline have been especially heavy in the southern Sierra. The damage caused by this fungus is similar in appearance and effect to that caused by dwarfmistletoe, and often the two are confused. Likewise damage by this needle disease is frequently confused with winter injury.

As a result of field appraisals we recommended that trees killed by the needle disease be removed from heavily used areas in Lassen National Park. In Sequoia National Forest we recommended salvage of dead trees and marking of infected living trees for logging. The disease was reported on pines around Lake Tahoe, but no action could be recommended for this area as yet.

Excluding white pine blister rust and heart rots, other destructive agents reported in 1955 included:

1. Comandra rust on ponderosa and Jeffrey pines, Klamath National Forest; experimental study plot recommended.

2. Limb blister rust on ponderosa and Jeffrey pines, San Bernardino, Inyo, and Toiyabe National Forests; salvage logging recommended on Inyo and Toiyabel.

3. Bole canker rust on lodgepole pine in the high Sierra.

4. Western gall rust on lodgepole pine along the North Coast.

5. Needle cast on white fir in Lassen, Shasta, and Plumas Counties and on ponderosa and Jeffrey pines in Lassen County.

6. Leptographium and Fomes root diseases on ponderosa and Jeffrey pines at Blacks Mountain Experimental Forest.

7. Winter injury on incense-cedar and other species east of the Sierra divide.

8. Physiological disease on Douglas-fir in Lassen County, Digger pine near Kern River, ponderosa pine in San Bernardino County, and redwood in Humboldt County.

SPRAY TESTS BEGUN ON MISTLETOE CONTROL

Tests seeking a more practical method of controlling dwarfmistletoe were begun on the Milford District of the Plumas National Forest. Partial control of the parasite can be obtained through drastic pruning and cutting in infected stands but this is costly and often leaves little standing for a future forest. It is also impracticable in infected high-value recreational

Broken tree, left, is a victim of dwarfmistletoe; on right is mistletoe canker--the type of injury leading to broken stems.

areas such as key campground and activity centers in some of our State and National Parks. If an herbicidal spray could be found that would kill the dwarfmistletoe without killing the host tree, it would provide a much more satisfactory method of control.

With the cooperation of a large manufacturer of herbicides, eight different chemicals are being tested in three series of spray applications. The first series was applied in late July and early August 1955 and a second in late September. A third series is planned for the late spring, just before the pine shoots start growing. Several years will be required to find whether the mistletoe parts embedded in the tissues of the host have been killed. If they have not, resprouting of the mistletoe will occur and the spray effects will be only temporary.

TREE SURVIVAL STUDIES AID IN FIRE SALVAGE

The disastrous fires that swept thousands of acres of timber in late August and early September killed everything in their paths on large parts of the burned area. In other parts the flames were not as intense and many trees were not killed outright though badly scorched. Immediately, owners and land-managing agencies were confronted with two big jobs: salvaging killed trees before deterioration became severe and saving as many damaged but not completely killed trees as possible as a source of seed to start new forests on the denuded slopes. However, many scorched trees not killed at the time of the fire are so badly damaged that they die later. One of the first problems in preparing for salvage was to tell which trees could be expected to live and which would probably die later from their injuries or from the attacks of bark beetles attracted by their weakened condition.

Fortunately Station pathologists had been studying the survival of sample fire-damaged trees on burns in California over a period of 15 years. Each tree was checked annually until the mortality rate on the burn in which it was located returned to normal. Detailed analysis of the studies had not yet been completed at the time of the 1955 fires, but a number of basic principles had become evident. These were outlined, first in a field training session on the Klamath National Forest, and shortly afterward in a Station research note.

Among the general principles outlined were:

1. The later the fire in the season, the better the chances of a severely damaged tree for survival.

2. The younger and thriftier the tree before the fire, the better the recovery prospects.

3. In ponderosa and Jeffrey pines, which form large well-protected buds, bud kill is more important than foliage kill in determining survival. More than 50 percent of live buds are usually needed for survival.

4. Heavy cambium injury reduces chances for survival but is difficult to estimate accurately. Sugar pine is especially susceptible to cambium killing at ground level because of the nature of its bark.

Detailed results of the studies will be prepared for publication as soon as possible.

NEW CIRCULAR PROVIDES TIMELY SALVAGE ADVICE

Information valuable in planning salvage of fire-killed timber was provided by Department of Agriculture Circular No. 962, issued by happy coincidence in late September. Describing the results of a long-time study of the rate of deterioration of fire-killed timber in California, the Circular tells how much time timber owners and operators have to salvage dead trees of different species and sizes before fungi and insects make them unsuitable or unprofitable to harvest. Very little deterioration occurs the first year, but the thick-sapwood species such as ponderosa and Jeffrey pines lose value rapidly after that time. On the other hand the larger trees of sugar pine and Douglas-fir may be profitably salvaged for years. White fir deteriorates faster than the other species, and only the larger white fir logs can be profitably salvaged after the second year.

A number of factors such as tree size and rate of growth, and the severity of burning, as well as the conditions of environment, influence the rate of deterioration. All such factors must be considered in combination for efficient planning of a particular salvage job.

The Circular explains that deterioration starts at the wood surface just under the bark and progresses inwardly. Some of the initial deterioration may be slabbed or trimmed off in lumber manufacture, but as the decay penetrates, the more valuable, knot-free outer portion of the logs is the first to deteriorate. It is pointed out that since the more valuable grades of lumber are lost first, the economics of salvage must consider the values as well as the volumes lost through deterioration.

FUNGI ASSOCIATED WITH CULL IN REDWOOD

Two decay fungi have been found the cause of practically all the cull in redwood timber. Although producing wood especially noted for its decay resistance, trees in the coast redwood stands of northern California contain more than 11 billion board-feet of cull due principally to decay in the heartwood. This is about 23 percent of the nearly 49 billion board-feet gross volume of these stands. A study recently completed by Station pathologists has revealed some new knowledge about the causes of cull in redwood.

One of the fungi, Poria sequoiae, was previously known to cause a brown cubical pocket rot in the butts of fire-scarred trees. This fungus causes 72 percent of the total cull caused by decay in redwood. It is not only a butt rot, but this study has shown that the brown rot occurs at any location in the bole where heartwood is exposed.

The other fungus, Poria albipellucida, not previously recognized in redwood, causes a white laminated or stringy ring rot, and is especially prevalent in the northern part of the redwood region. In the northernmost county, Del Norte, it causes 55 percent of the cull caused by decay ; in the entire redwood region, 28 percent. Like the brown cubical rot, this white ring rot may occur at any location in the heartwood of the bole.

Both fungi may gain entrance through exposed heartwood in the bole, and the more common entry courts are fire wounds and broken tops. Any wound, however, that exposes heartwood in the bole may serve as an entry point for either fungus. Broken branches were not found to be entry points for these organisms. An unidentified brown cubical pocket rot decays the thick, fire-resistant, basal bark on some redwood trees. It is believed that repeated fires burning out these decayed pockets start fire wounds in these trees.

IMPROVED METHODS DEVELOPED FOR DETERMINING BLISTER RUST

A serious handicap to control forces in determining the spread of white pine blister rust to new areas of sugar pine in the Sierra Nevada appears to have been overcome in a cooperative project between the Station and the Plant Pathology Department of the University of California.

The rust first appears in new locations on the leaves of currants and gooseberries, collectively known as Ribes, and this gives a clue to where it will later appear on sugar pines. However, another rust, which will infect only pinyon pines, also is found at times on Ribes leaves in the Sierra Nevada. The two rusts can rarely be told apart when found. A laboratory staining method for distinguishing between them was developed some years ago but was time-consuming and required considerable experience in application. Furthermore, the results were not always clear cut. A simpler and more certain method of diagnosis was needed.

The new studies have developed not only a much simpler and faster laboratory test for distinguishing blister rust from pinyon rust, but also a field testing technique by means of which diagnosis can be made where the rust is collected. The field method has not yet been tested by rust scouts but no difficulties in its use are foreseen. It will make scouting results immediately available to field men rather than having to wait for delayed and sometimes uncertain reports from a central laboratory.

CALIFORNIA PINE SPECIES INDICATE RUST RESISTANCE

Several trees discovered in the course of forest disease surveys give new encouragement to the possibility of producing pines resistant to the white pine blister rust. Foxtail pines growing in the Marble Mountain area on the Klamath National Forest showed no rust infection even though western white pines and whitebark pines growing nearby were heavily infected. Although the foxtail pine is not a commercially available species, it has good form and attains large size for an alpine tree. If further observations and studies confirm that this white pine species is resistant to the rust, there is a possibility that it could supply rust-resistant genes for breeding resistant hybrids.

Sugar pine in a heavily infected rust center on the Plumas National Forest has indicated resistance in some individual trees. Three young trees, 6 to 10 inches in diameter, have no visible white pine blister rust infection where all surrounding trees are heavily infected. Some of the adjoining trees, of the same age class, have more than a thousand cankers and many have been killed by the rust. Some have been dead at least 4 or 5 years.

Apparently rust-free sugar pines have previously been found under heavy rust conditions both in Oregon and in northern California. Such cases strongly suggest that some sugar pines are rust resistant, and give us hopes that a resistant strain of this species may be developed by selective breeding.

LOCAL CLIMATIC EFFECTS ON BLISTER RUST STUDIED

Lower-cost blister rust control is the ultimate objective of a new study of the way climate affects development of the rust. For some time those concerned with protecting California pines from destruction by the disease have realized that more information was needed on the effects of local climate on rust hazard to five-needled pines. Within the past 2 or 3 years this conviction has been strengthened by results of research in

the Lake States. This work indicated that temperature has a greater effect than previously realized in restricting damage by the rust; the low incidence of rust on white pines in southern Wisconsin was traceable to the influence of temperature and other elements of local climate. In California, more definite information in this field appears to offer the best current prospect for a further reduction in the costs of protecting sugar pine from the rust. Knowledge of climatic effects could provide a basis for greater selectivity in the removal of Ribes species, the alternate hosts for the disease.

During 1955, obstacles that in the past have stood in the way of beginning such studies in California were overcome, and a modest cooperative start was made on them by the Department of Plant Pathology of the University of California with funds supplied by the Station. The work will continue in 1956, and we hope that means can be found for expanding it to a point commensurate with its promise for protection of sugar pine from the rust.

GROWTH OF HEART ROT FOLLOWED IN NEW STUDY

Another study begun during the year is aimed at reducing losses from heart rot in standing timber. Cull from heart rots is recognized as a major form of loss in the forests of California. The only practicable way known to reduce losses is to harvest the trees with rot, but not all of them can be logged immediately. Priorities in cutting on timber holdings are necessary. In determining where to log first, the forest manager is often confronted with the question of how much will be lost from decay if a species with some decay present is left for the next cut. How fast can the decay be expected to progress?

One of the chief factors governing the rate of decay is the temperature inside the tree where the fungus causing the decay is growing. The rate of progress of a decay fungus increases with temperature up to a certain optimum point, which varies with the particular kind of fungus, and then drops off rapidly as higher temperatures are reached, to a point where the fungus becomes dormant. To find out how temperatures in the heartwood of trees of different sizes and species vary under different conditions, the Station is beginning continuous temperature measurements within sample trees, to extend for a year or more. These will be recorded on charts and the record compared with the growth curve for two of the chief heart-rotting fungi responsible for decay in California timber. It is anticipated that this comparison will provide a useful index of how fast decay may be expected to progress in different parts of the State and at different elevations.

RANGE MANAGEMENT RESEARCH

1955 SIGNIFICANT YEAR FOR RANGE MANAGEMENT RESEARCH

During 1955 the range research staff concentrated on summarizing progress made in three major fields of study: Artificial revegetation, brushland conversion, and management of northeastern California rangelands. A complete bulletin has been printed and distributed on the first subject and substantial progress on the other two has been made with manuscripts now in final stages of completion. M. W. Talbot, in charge of the Station's range management research program for more than 20 years, retired during the year after contributing materially to all three summary reports. He has been succeeded by E. J. Woolfolk, who has had range research experience in the northern Great Plains, the northern Rockies, the Southeast, and in the Washington Office of the Forest Service.

Progress also was made in solving the highly complex problem of how to seed browse plants on deer winter ranges. This is a Pittman-Robertson Federal Aid project in cooperation with the California Department of Fish and Game. The project is primarily concerned with reseeding bitterbrush, California's most important deer browse plant, on semi-arid eastside ranges.

The Station's program at the San Joaquin Experimental Range was on a maintenance basis during the year owing to emphasis on summary publications and recruiting problems. By year end, however, we had two men on the job at the Range and were in a position to resume grazing management studies there. The University of California Animal Husbandry Department is continuing its studies.

PROGRESS MADE IN RANGE SEEDING AND WEED CONTROL RESEARCH

In October, Agriculture Handbook 88 was issued, summarizing our work on rangeland improvement through seeding and weed control on the east slope Sierra Nevada and on southern Cascade mountains. This bulletin, based on 8 years of study, gives ranchers and rangeland managers practical methods for seeding and weed control on deteriorated range lands. It was prepared in cooperation with the Agricultural Research Service, the agency which has handled range seeding, fertilization, and weed control research since the Department of Agriculture reorganization in 1954.

Tall growth of grasses with high grazing capacity on improved range at right resulted from plowing and seeding weedy meadow like that at left.

New studies in range seeding were conducted by Agricultural Research Service cooperators at several localities. At the Station's Blacks Mountain branch on the Lassen National Forest, this work is comparing different strains of intermediate wheatgrass and smooth bromegrass. Also in the first stages of testing there are bluegrass hybrids produced by the Carnegie Institution of Washington and rye hybrids produced by the Department of Genetics, University of California. Tests of grass and legume strains were expanded to include several locations on burned-over chaparral land in the south Sierra Nevada and Coast Range mountains.

LARGE-SCALE RANGE PLANTINGS OF BITTERBRUSH POSSIBLE

Recent experience in two northern California locations has shown that bitterbrush can be successfully seeded on big-game ranges. Both spring and fall drilling of 8 pounds of seed per acre on cultivated seedbeds yielded seedling stands of 4,600 to 8,000 plants per acre at the end of the first growing season. Rodents ate a great deal of the sown seed, and drought, insects, and destructive agents claimed many emerged seedlings. As a result, surviving seedlings amounted to less than 7 percent of the number of viable seed planted. In

spite of this low ratio of seedlings to viable seed planted, both stands are considered satisfactory under arid range situations.

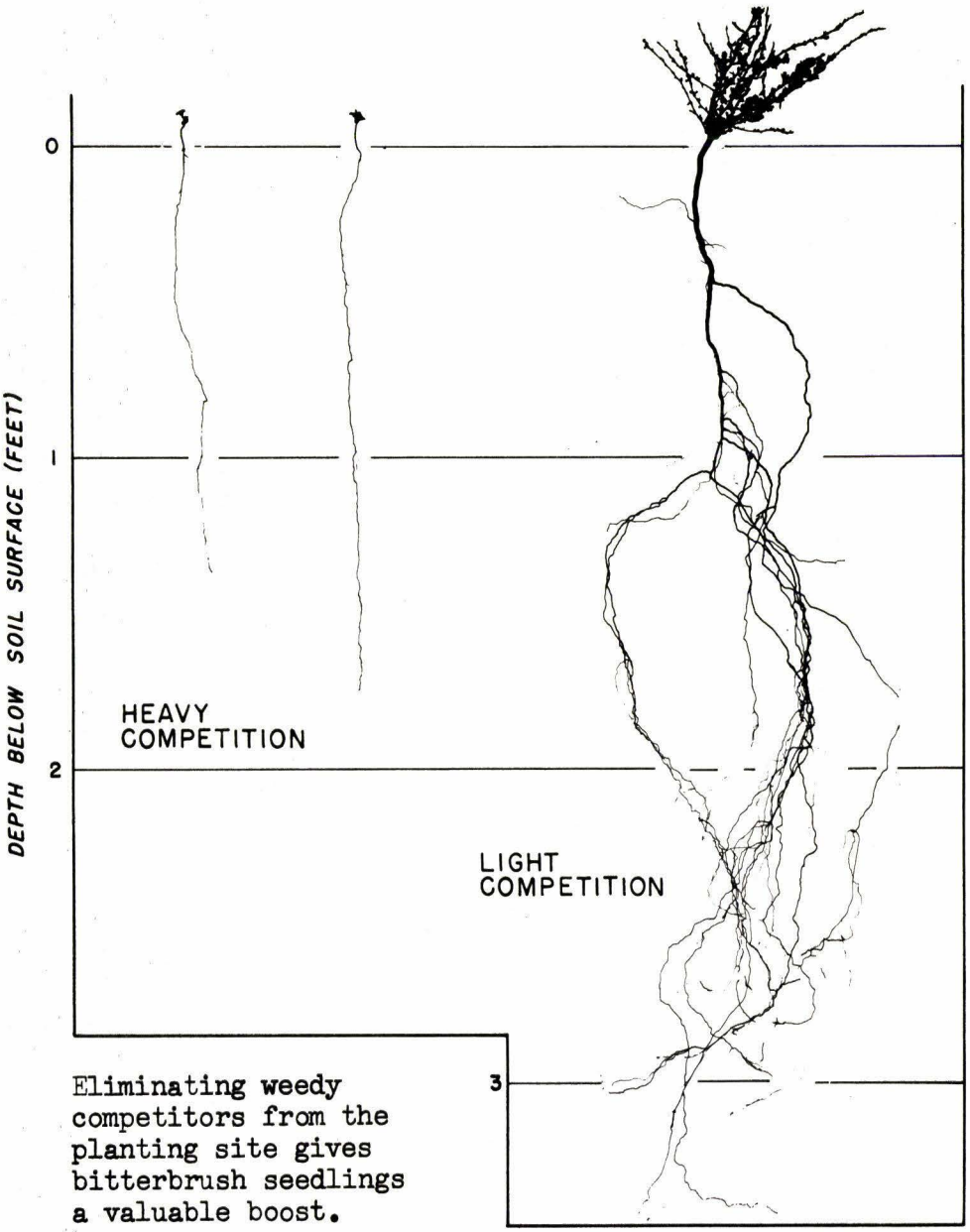
Similar pilot plantings on uncultivated but burned range sites gave entirely unsatisfactory stands of bitterbrush seedlings. Even though emergent stands averaged nearly 1,300 seedlings per acre, they were almost completely lost by the end of the first growing season because of drought and browsing by rabbits. It is plain that successful bitterbrush plantings will require attention to a great many details which are being studied in the browse-restoration project.

SITE TREATMENT ESSENTIAL FOR SUCCESSFUL BITTERBRUSH PLANTING

One important lesson from the browse studies is that seedbed preparation and weed control are beneficial in improving the success of bitterbrush plantings. Growth of bitterbrush seedlings on a site plowed and harrowed before fall planting and kept relatively free of competing vegetation through three growing seasons has exceeded the growth of seedlings on an undisturbed big sagebrush site by more than five times. On another site, plowed and harrowed before planting but not weeded thereafter, growth rates were intermediate. Average seedling heights under different degrees of competition were as follows:

	Light competition	Moderate competition	Heavy competition
	- - - - (inches) - - - -		
First year	6.0	4.7	1.3
Second year	13.8	9.5	2.6
Third year	26.0	18.2	4.5

Further evidence of the benefits of seedbed preparation and weed control was found by comparing the root systems of seedlings on the areas having light and heavy competition. During the first growing season, seedling roots penetrated to a soil depth of 42 inches and were widely branched on the weeded site. On the undisturbed site, where competing vegetation was heavy, seedling root systems consisted mainly of thin, unbranched taproots not over 30 inches in length. It is evident that seedbed preparation and subsequent weeding facilitate the establishment of bitterbrush seedlings and better prepare them to withstand drought and other adverse conditions. Seedbed preparation



alone was highly beneficial. Judging from these data this pre-planting site treatment will pay big dividends in easier establishment and accelerated growth of bitterbrush seedlings wherever its use is feasible.

THIOUREA SEED TREATMENT NOT YET PRACTICAL

Studies completed during the past year have verified the earlier conclusion that thiourea was effective in breaking seedcoat dormancy in bitterbrush. However, residual effects of the chemical on seedling emergence and survival may be detrimental. Laboratory tests have shown that bitterbrush seed soaked for 5 minutes in a 3 percent solution of thiourea will give a germination percent of 85 in 15 days, compared to 71 percent for stratified seed and only 2 to 4 percent for untreated seed. This finding appeared to be the key to successful spring planting without the usual difficulties of handling wet stratified seed.

In subsequent field plantings, however, the advantages of quick germination due to thiourea treatment appear to have been partly lost on some sites. For example, on the Wells Meadow and Doyle areas, seedling emergence from spring 1955 plantings of thiourea-treated seed was only 16 percent. Spring-planted stratified seed gave 49 percent seedling emergence. At the Flukey Spring site, seedling emergence was 59 percent with thiourea-treated seed from spring planting. Stratified seed planted in spring gave 69 percent seedling emergence.

About the same pattern developed in seedling survival through the 1955 growing season. Survival from spring-planted stratified seed was 10 percent at these locations; but from thiourea-treated seed, survival was only half that amount. At Flukey Springs, seedling survival was 73 percent from plantings made with stratified seed. With thiourea-treated seed, seedling survival was 64 percent. These results indicate that the effects of thiourea must be better known before its use can be considered practical.

OPTIMUM PLANTING DEPTH FOR BITTERBRUSH HIGHLY VARIABLE

That bitterbrush seeding techniques may need to be tailored to the site and time of planting is suggested by studies of depth of planting. Based on percent of bitterbrush seedling emergence, the optimum depth of planting has varied in recent studies from one-half to two and one-half inches (table 3). Three locations, four planting seasons, and two growing years were represented in these tests. At Flukey Springs in northern California and Doyle near the Nevada line in north central California, optimum planting depth has been slightly less than an inch for all plantings. The optimum has been slightly shallower at Flukey Springs than at Doyle. At Wells Meadow in extreme east central California approximately

1-1/3 inches has been the best planting depth. As is well known, precipitation and soil fertility both decline from Flukey Springs through Doyle to Wells Meadow. Slightly greater spring than fall planting depths gave best emergence at each location and for all locations when combined. The optimum depth for the 1954 growing season, slightly more than an inch regardless of locations or season of planting, was about a third of an inch deeper than the optimum for 1955. These findings indicate clearly that the success of bitterbrush plantings on California deer winter ranges depends directly on depth of planting in relation to season and year of planting by geographic regions.

Table 3.--Optinum planting depths and percent seedling emergence from each at three locations during two different growing seasons

Area and year of emergence	Time of planting	Optimum depth	Average emergence from optimum depths
		Inches	Percent
Flukey Springs			
1954 1/	Fall 1953	1/2 - 1 1/2	20
	Spring 1954	1/2 - 1	50
1955 2/	Fall 1954	1/2 - 1	41
	Spring 1955	1/2 - 1	16
Doyle			
1954	Fall 1953	1/2 - 1	30
	Spring 1954	1/2 - 1 1/2	17
1955	Fall 1954	1	48
	Spring 1955	1	14
Wells Meadow			
1954	Fall 1953	1 - 2	21
	Spring 1954	1 1/2 - 2 1/2	15
1955	Fall 1954	1/2 - 1 1/2	65
	Spring 1955	1/2 - 1	18

1/ Based on 100 seeds
2/ Based on 500 seeds.

GENETICS OF SPROUTING IN BITTERBRUSH BEING STUDIED

Sprouting in bitterbrush is uncertain and poorly understood. There is no known record of complete stand rejuvenation through sprouting after fire. On the other hand, a few instances of partial stand replacement by sprouting are known. Determination of the nature of sprouting, that is, whether it is a heritable characteristic or due to environment, and discovery of a sprouting strain of bitterbrush would greatly enhance the study of bitterbrush seeding on deer winter ranges. A project started during the year in cooperation with the University of California School of Forestry and with cooperative aid funds is expected to determine the nature of this plant characteristic. A number of sprouting bitterbrush plants have been discovered on one area and isolated sprouting plants have been found in several other localities. This material will be used in the new studies.

These year-old sprouts of bitterbrush grew from buds just below the soil surface in one of the comparatively rare stands where sprouting occurred after a fire.

HARVEY VALLEY RANGE MANAGEMENT SYSTEM YIELDING PROMISING RESULTS

The past year, 1955, was the driest on record in northeastern California, but the Harvey Valley range allotment on the Lassen National Forest continued to provide 4 months of grazing for 500 cattle and thus demonstrated another advantage of the range management system being pilot tested there.

The Harvey Valley pilot grazing study is now in its fourth year. This study, in cooperation with the administrative branch of the Forest Service, is applying on a practical scale range improvement and management techniques developed through research. In 1955 four of the five range units at Harvey Valley were used as provided by the management system for emergency situations or during times of stress. Ordinarily only three units are grazed in any year and two are rested.

With only 9.5 inches of precipitation to the end of September in 1955 against an average of 17.7 inches, only 60 percent of the usual amount of grazable herbage was produced on the allotment. Planned grazing use in an average year allows 33 percent for one unit, 66 percent for two units, and zero use for the other two. For the allotment as a whole the plan is to remove a third of the grazable herbage each average year. Freedom to increase grazing use to 66 percent on four units and about 11 percent on the fifth for an allotment average of 55 percent, is also in the plan to take care of stress periods. In 1955 the emergency plan was followed. Grazing use averaged 46 percent for the entire allotment; only one unit received more than the maximum 66 percent planned, and one unit remained ungrazed throughout the season.

Thus, grazable herbage was left on the range at the close of the grazing season in the driest year on record. This fortunate situation is undoubtedly the result of 4 years of improved management plus the increase in herbage production through artificial reseeding, sagebrush removal, fencing, and other improved range practices. Starting at an average weight of 536 pounds on June 11, 39 head of 2-year-old Hereford steers gained 1.74 pounds per head per day until October 1, for a total gain of 195 pounds on this range. According to their owner, these steers looked better at the end of the season than similar groups taken from adjacent ranges in earlier and better years. The superiority of the Harvey Valley cattle in spite of the drought, was due to application of improved management on the Harvey Valley allotment.

Fat cattle, abundant grazable herbage, and stable watershed conditions are products of good range management.

WATERSHED MANAGEMENT RESEARCH

OPERATION WET BLANKET STARTED IN SNOW ZONE

Research in snowpack management got underway this year. The research will seek ways to improve the water yield of some 9 million acres of the commercial forest zone above the Central Valley at elevations where the snow blanket lies deep well into the dry season. This area yields nearly 40 percent of California's streamflow. Our aim is to learn how forests there should be cut and other lands treated so that winter floods will be reduced, dry-season flow prolonged, and total water yield safely increased.

Studies in other regions, and exploratory investigations in California, indicate that the way the forest is cut has considerable influence over the way water is yielded from the snowpack. We hope to develop methods of land management that will improve snow water yield. These methods can be applied when the State's high-elevation forests are cut and placed under sustained yield management.

The studies contemplated in California fall under four headings:

1. Map the areas where amounts and timing of snow melt are markedly different under present cover conditions;

2. Map the different forest types and densities in the snowpack zone;

3. Develop methods of land treatment for controlling the melt rate and water yield under different snowpack and forest conditions;

4. Apply the most promising methods of snowpack management on small calibrated watersheds and measure their effect on the yield of water.

To conduct this research, a small staff is now at work and one of two available snow laboratories has been activated. If present prospects for cooperative assistance in this research materialize, the staff will be expanded and the other snow laboratory will be activated. Already in operation is the Teakettle Snow Laboratory, in the Kings

River Basin. The other is the Central Sierra Snow Laboratory, in the headwaters of the Yuba River.

The Teakettle Snow Laboratory was established in 1938. A laboratory building was constructed at that time and four small forested watersheds were equipped with reservoirs to catch sediment and gages to measure streamflow. The laboratory was operated 2 years and then closed because of lack of funds. Since establishment, however, the reservoirs have caught sediment delivered from their watersheds, and the accumulated sediment has been measured from time to time. These measurements provide an opportunity to evaluate sedimentation in watersheds on which the timber will later be cut to pilot-test the promising methods of snowpack management. We need this evaluation because one objective of snow research is to learn how to improve water yield without excessively increasing sedimentation.

Analysis of the sediment records showed that the sedimentation rates in three of the watersheds were similar. When corrected for trap efficiency of the reservoirs, sedimentation rates for the three watersheds averaged 0.017, 0.018, and 0.020 acre-feet per square mile per year. The fourth watershed, in which a small burn occurred in 1943, had about double the sedimentation rate of the others--0.034 acre-feet per square mile per year. These results indicate that sediment production from this type of watershed is very low when the forests are in virgin condition.

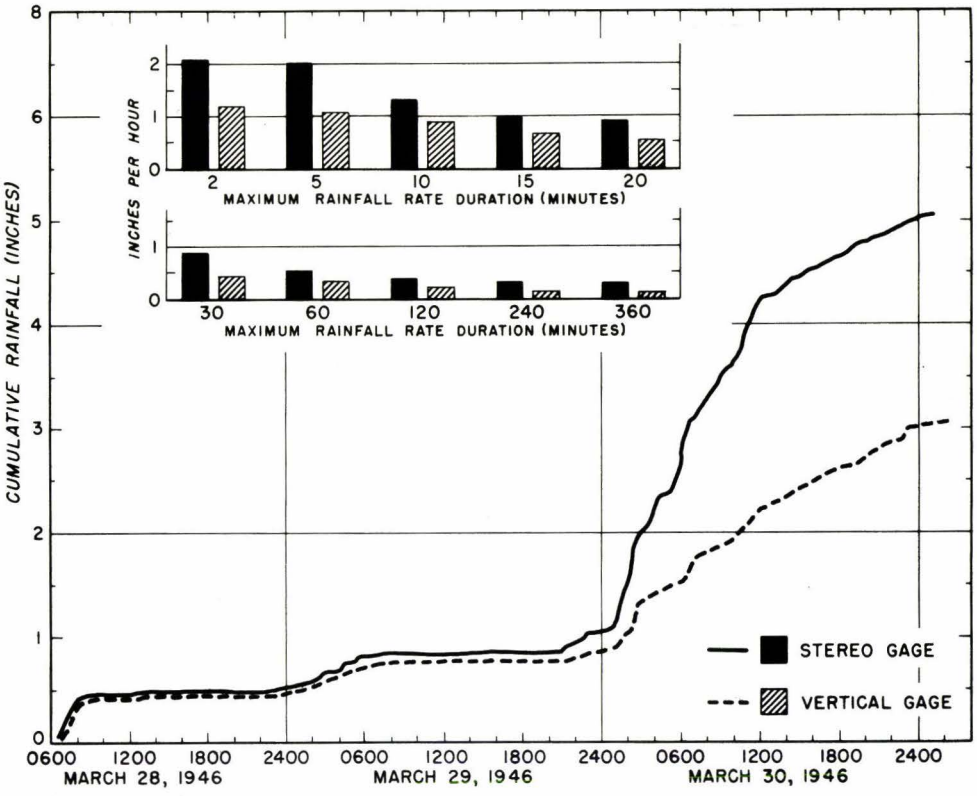
ACCURACY IN DETERMINING RAIN RATES IMPROVED

In watershed management we need to know rainfall rates, that is, how much rain falls in a given time. Rainfall rates are measured by recording rain gages which produce a continuous graphic record of the quantity of rainfall caught by the gage. We have found, however, that rate determinations are sometimes seriously in error when based on records of conventional recording rain gages situated on steep mountain slopes. If correct determinations are to be made, the receiver tube of the recording gage must be cut on the bias so that its rim is parallel to the ground rather than horizontal. This has the same effect as tilting the whole gage, a change we earlier found necessary for accurate rain measurement with a standard rain gage on mountain slopes.

A stereo recording raingage on the San Dimas Experimental Forest.

The storm of March 28-30, 1946, provides an illustration of how the measured amount and rate of rainfall differ between a conventional and an altered gage. The two gages stood 50 feet apart in brush cover, on a south-facing slope of 44 percent gradient, in the head of Monroe Canyon on the San Dimas Experimental Forest. The receiver tube of one gage had the usual horizontal circular opening while the opening of the other, termed a "stereo-gage," was cut to slope parallel to the land surface about it. At the end of the 67-hour storm, the stereo gage contained 5.27 inches of rain and theconventional gage 3.25 inches. Since we knew that the stereo gage gave the correct measure of rainfall, the catch of the conventional gage was 39 percent low. Furthermore, the rain rate indicated by the conventional gage, averaged over the 35 hours of actual raining time, was .09 inch per hour, .06 inch per hour less than the correct rate shown by the stereo gage.

The hydrologist requires information on rainfall rates for shorter periods than an entire storm, and usually breaks storms into intervals of various lengths. The accompanying chart shows how records for a number of intervals


CUMULATIVE RAINFALL (INCHES)
INCHES PER HOUR
MAXIMUM RAINFALL RATE DURATION (MINUTES)
MAXIMUM RAINFALL RATE DURATION (MINUTES)
STEREO GAGE
VERTICAL GAGE
0600 1200 1800 2400 0600 1200 1800 2400 0600 1200 1800 2400
MARCH 28, 1946
MARCH 29, 1946
MARCH 30, 1946

Storm rainfall records produced by conventional and stereo recording rain gages, March 1946.

compare between the two gages for the 1946 storm. For the maximum 5-minute period, for instance, the conventional gage indicated a rate of 1.08 inches per hour, while the stereo gage indicated 2.04. Over the time periods shown, the conventional gage rate ranged from 32 to 58 percent lower than that of the stereo. Errors of these magnitudes are too large to be acceptable in many watershed management studies, yet such errors are fairly common in conventional gages exposed to heavy storms in the high, steep mountains of southern California because the vegetation there is not sufficiently high nor dense to shelter the gage from the wind.

NEW GAGE NETWORK SIMPLIFIES MEASUREMENT OF RAINFALL

We have found that we can measure rainfall on the 17,000 acres of the San Dimas Experimental Forest with 17 rain gages as well, for most purposes, as we did formerly with 77 gages--and better than we did in earlier years with 200 gages. This reduction in the number of gages was accomplished by a series of studies which showed that for most storms the variation in rainfall over a mountain area of this size is not as great as had been anticipated.

We expended much effort 20 years ago in laying out a network of gages which would sample all the variations in rainfall which were assumed to exist in this area of rugged topography. The network consisted of 200 rain gages spaced one-half mile apart along contour trails located at altitudinal intervals of 1,000 feet. Using this network we studied the variations in rain catch and the accuracy of rainfall sampling. We learned that much of the indicated rainfall variation was caused by inaccuracy in raingage catch. This error was corrected when the gages were tilted normal to the slopes on which they stood, and this made it possible in 1950 to reduce the network to 77 gages.

Then data from the 77-gage network were examined to determine if further reductions were possible. We asked whether the average catch of rainfall at each elevation in each watershed was closely related to the catch of a single key gage at the top and bottom of the watershed. It was decided that if the average catch at each elevation could be predicted from the catch of the key gages within a standard error of 0.25 inch, then we need measure rainfall, storm by storm, only in those key gages.

We found that two key gages, one at the top and one at the bottom of the watershed, gave satisfactory predictions when the range of elevation did not exceed 2,000 feet. For watersheds with an elevation range of 3,000 to 3,500 feet, three gages were necessary. In all cases the key gages met the requirement; storm rainfall predictions for elevational zones in watersheds had standard errors less than 0.25 inch, ranging from 0.06 to 0.21 inch.

As finally established, the new rainfall sampling network comprises 17 key gages well distributed over the Experimental Forest both as to area and altitude. The final step was to install a recording gage at each key location so that rainfall rates as well as total storm amounts could be obtained. Thus rainfall measurement in a mountain area of southern California has been greatly simplified through a progression of basic studies about rain and by the practical application of the principles developed from these studies.

INSTRUMENTS DEVELOPED FOR WATERSHED RESEARCH

Other research measurements have been simplified by instruments developed on the San Dimas Experimental Forest. A soil sampler developed there has been used successfully to obtain virtually undisturbed cores of soil to depths of 17 feet. This instrument was needed to sample soils in experimental plots which could not be disturbed by

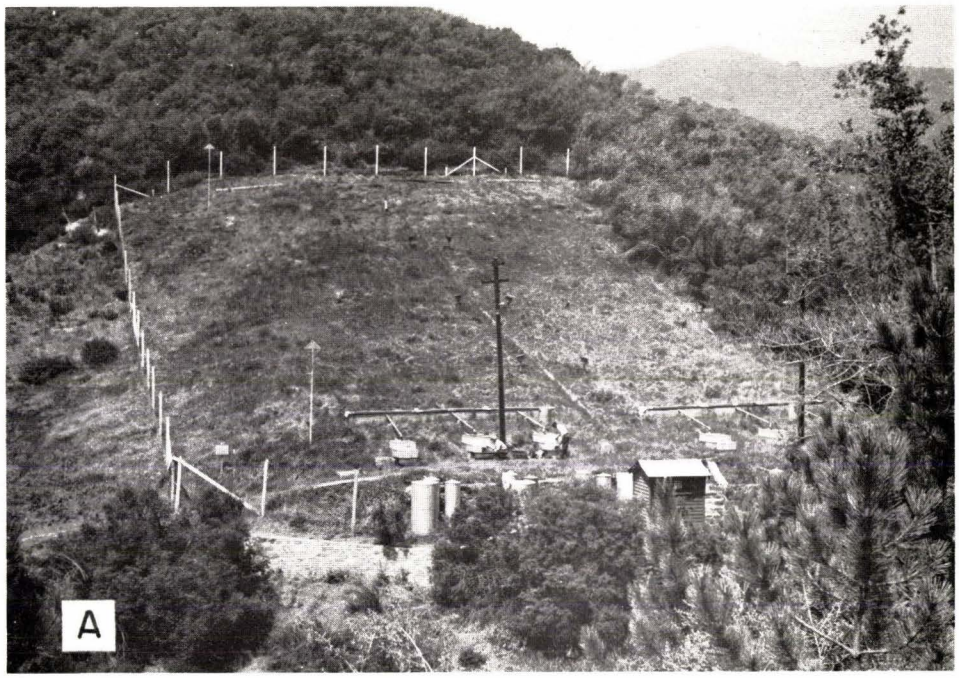
excavation. The San Dimas sampler is distinctive in having a cutter which rotates around a stationary inner collector tube. The cutter removes the soil around the cutting head, carrying it upward and away from the tube and thus avoiding compaction of the soil sample. A smaller model of the San Dimas sampler has been used widely on the Forest Service Infiltration Project conducted in cooperation with the Corps of Engineers at Vicksburg, Mississippi. The Infiltration Project and the Experiment Station are preparing a joint publication describing these samplers and their use.

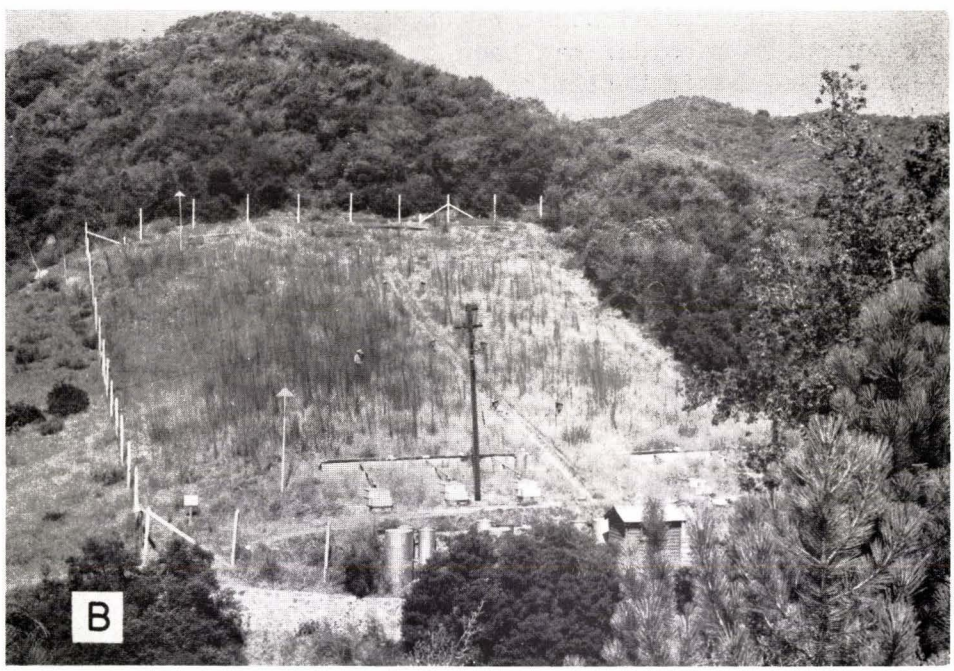
The problem of indicating peak streamflows at gaging stations where continuous flow records are not maintained was solved on the San Dimas Forest with development of a simple indicating device. This device is operated by a float in a stilling well. A steel measuring tape attached to the float passes up and over an indexed pulley. It also operates a rachet and pawl on the pulley shaft which prevent the float from dropping when streamflow recedes. The maximum water stage can be read on the tape after the streamflow peak has passed.

A reversal-indicator attachment for the Friez FW-1 water stage recorder has been developed on the San Dimas Forest to obtain better records of fluctuating streamflow. The device employs a special pen which marks along the bottom margin of the recorder chart. This pen changes position each time the regular recorder pen reverses direction upon reaching the top or bottom of the chart. Having the reversals designated on the chart aids in the correct interpretation of streamflow records.

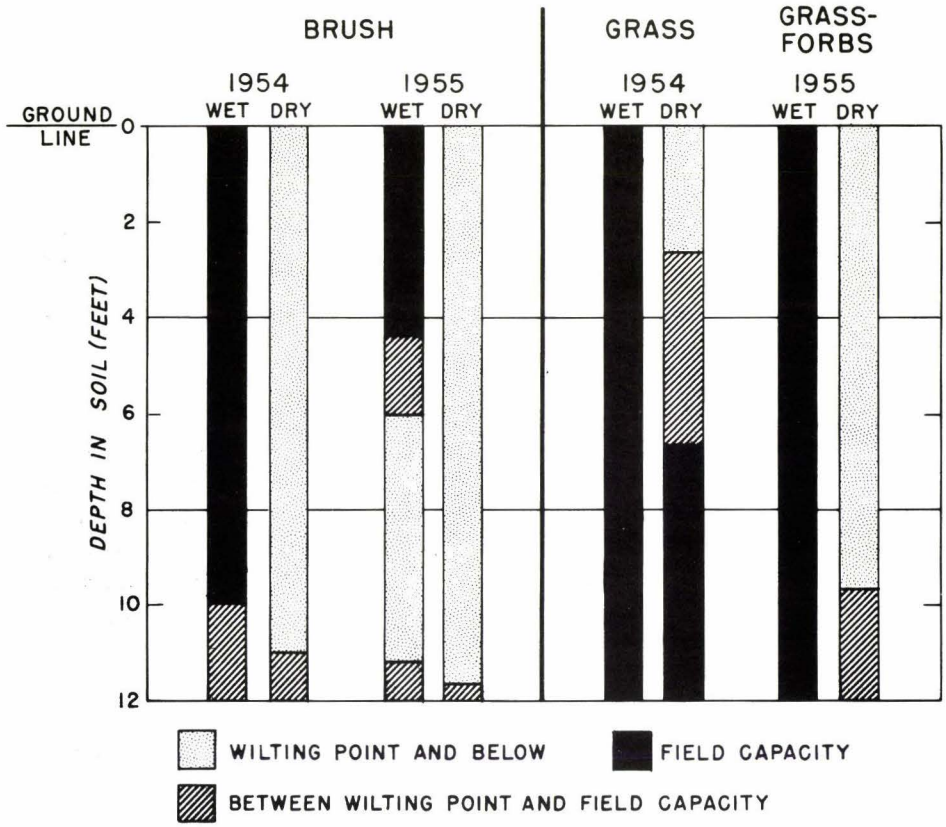
WATER USE BY BRUSH, GRASS, AND GRASS-FORBS COMPARED

A plot study on the San Dimas Experimental Forest indicates important differences in evaporative loss from deep soils covered with oak-brush, annual grass, and annual grass-forb vegetation. The plots studied were originally covered with dense scrub oak and other native brush. In the winter of 1951-52 two sets of plots were converted to annual ryegrass and the brush on the third set was left undisturbed. During the next 2 years a grass cover was maintained on the converted plots by killing all brush sprouts, seedlings and forbs by spraying with 2,4,5-T. During the third year, 1954-55, these plots were not sprayed, and a growth of native broad-leaved herbs developed. Soil moisture was measured after storms and at weekly intervals in all plots by means of electrical moisture indicators placed at various depths from near the surface to bedrock. The soil averages about 12 feet deep.





Cover converted from brush to grass; A, with the native forb growth prevented by spraying with 2,4,5-T; B, with native forb growth uncontrolled.



Water-use differences under brush, grass, and grass-forb cover.

The soil of the undisturbed brush plots was wet to field capacity through the 12-foot depth during the first winter, when rain totalled 41 inches. But during the next three winters, rainfall was only 15, 25, and 20 inches, and the soil was wet to field capacity to depths of only 4, 10, and 4.5 feet. Each summer evapo-transpiration dried the entire soil of these plots to near or below wilting point, and rain was insufficient after the first year to re-wet it fully.

In the plots converted from brush to grass the soil was wet to field capacity through its entire depth each rainy season. During the first three summers the soil beneath the grass cover dried below field capacity to an average depth of only 7 feet and below wilting point to an average depth of 3.2 feet. Consequently, there was a greater carry-over of water at the end of each summer in the 4- to 12-foot depth of soil under grass than under brush. In 1955, however, when the native forbs were permitted to grow, soil

throughout the 12-foot depth was nearly as dry by the end of summer as under the brush.

The study indicates that, in the mountains of southern California, evapo-transpiration from brush- or grass-covered soils less than 4 feet deep would be about the same. No additional water yield would result from converting the cover on these soils from brush to grass. For soils deeper than 4 feet, conversion from brush to grass would result in more water yield in years of rainfall sufficient to wet the soil below this depth, but only if the growth of broad-leaved herbs is prevented.

RAINFALL DISPOSITION IN A WATERSHED DETERMINED

Analysis of 15 years of hydrologic records from an 875-acre, brush-covered watershed in the San Dimas Experimental Forest indicates that there is wide variation in the disposition of annual rainfall. Amounts of annual streamflow, percolation, and water yield varied widely in response to the amount and distribution of each year's rainfall (table 4).

Streamflow ranged from less than .05 inch in a year with 12.4 inches of rain to 11.0 inches when the year's rainfall totalled 51.6 inches. Streamflow, however, does not account for the total water yield of this watershed because some of the water percolates deep into the underlying fractured rock and leaves the watershed underground. Total yield was calculated by a bookkeeping system in which periodic evaporative losses were subtracted from precipitation, these losses having been determined by field study in the watershed. Thus calculated, annual water yield was less than .05 inch when 12.4 inches of rain fell, and 32.8 inches when 51.6 inches rain fell. Over the 15 years of record streamflow averaged 3.0 inches; total water yield, 11.7 inches. Ordinarily between one-third and one-sixth of the total water yield appeared as streamflow at the mouth of the watershed.

Year to year variations in evaporative loss were much smaller than the variations in total water yield. Annual evaporative loss ranged from 12.4 to 18.8 inches and averaged 15.4 inches. The magnitude of this loss was influenced by the size, number, and distribution of storms in a year and, during years of low rainfall, was limited by the amount of water available for loss. In 7 of the 15 years rainfall was inadequate to wet all the watershed soil to field capacity.

Table 4.--Rainfall disposition in Monroe Canyon, San Dimas Experimental Forest

Hydrologic year	Precipitation	Streamflow	Evaporative loss[1/]	Percolation[2/] less streamflow	Water yield[3/]
	- - - - - - - - Inches depth - - - - - - - -				
1938-39	20.4	1.2	13.4	5.8	7.0
1939-40	27.2	1.0	18.3	7.9	8.9
1940-41	51.6	11.0	18.8	21.8	32.8
1941-42	17.7	0.9	15.2	1.6	2.5
1942-43	43.8	10.6	17.0	16.2	26.8
1943-44	31.8	4.6	15.6	11.6	16.2
1944-45	31.1	3.3	15.4	12.4	15.7
1945-46	26.6	2.4	14.6	9.6	12.0
1946-47	29.4	2.1	17.2	10.1	12.2
1947-48	15.0	0.2	14.0	0.8	1.0
1948-49	18.3	0.3	13.9	4.1	4.4
1949-50	21.3	0.5	14.3	6.5	7.0
1950-51	12.4	4/T	12.4	0	4/T
1951-52	43.9	6.1	17.9	19.9	26.0
1952-53	16.0	0.3	13.1	2.6	2.9
Average	27.1	3.0	15.4	8.7	11.7

1/ Evaporative loss includes interception loss, evapotranspiration, and riparian water loss.

2/ Percolation through root zone = precipitation - (Streamflow + evaporative loss) all cumulated from beginning of hydrologic year (October 1). This percolation is assumed to be a measure of subsurface yield, but the time and place of delivery of this yield is unknown.

3/ Water yield = streamflow + percolation.

4/ Less than .05 inch.

PUBLICATIONS

Ackermann, W. C., Colman, E. A., and Ogrosky, H. O.
From ocean to sky to land to ocean. Water. U. S. Dept. Agr. Yearbook 1955: 41-48, illus.

Describes the hydrologic cycle and points out where man can exert influences over water.

Anderson, H. W.
Detecting hydrologic effects of changes in watershed conditions by double-mass analysis. Amer. Geophys. Union Trans. 36: 119-125, illus.

Shows one way of detecting the effects of wildfires on sedimentation and flood peaks, and illustrates how to take into account such effects when estimating long-term sedimentation and flood frequency from the short-term records usually available.

Arnold, R. K., Buck, C. C., and Fenner, R. L.
Area ignition for brush burning. Calif. Forest and Range Expt. Sta. Tech. Paper No. 10, 10 pp., illus.

Describes the area ignition system of firing for safer, more effective controlled burns in land clearing. Guidelines for area-ignition mechanics and precautions are given. The brush-smashing technique for fuel preparation before area-ignition firing is also described.

Ashby, William C., and Hellmers, Henry
Temperature requirements for germination in relation to wildland seeding. Jour. Range Mangt. 8(2): 80-83.

Describes a study designed to determine the relationship of temperature to germination of various grasses and forbs that are considered promising for seeding of wild lands in southern California.

Averell, James L., Crowell, John C., Quick, Clarence R., and Schubert, Gilbert H.
Sugar pine management--an annotated bibliography. Calif. Forest and Range Expt. Sta. Tech. Paper 12, 56 pp. illus.

Describes publications that have a bearing on the growing of sugar pine for timber production. This annotated bibliography is intended primarily for the information of forest managers.

Baker, H. L. And Poli, A.
Area and ownership of forest land in Tehama County. California Forest and Range Expt. Sta. Forest Survey Release 26. 23 pp., illus.

Presents Forest Survey figures of land area for nonforest, noncommercial forest, and commercial forest land. Area of commercial forest land shown by timber type, age class, ownership, and size of holding.

Callaham, R. Z.
Sapwood moisture associated with galleries of Dendroctonus valens. Jour. Forestry 53: 916-7.

A preliminary study of the moisture content of sapwood underlying galleries of the red turpentine beetle. It was concluded drying of the sapwood directly beneath the beetle's galleries contributed to the ultimate death of the tree.

Childs, H. E., Jr., and Howard, W. E.
The vertebrate fauna of the San Joaquin Experimental Range. Calif. Forest and Range Expt. Sta. Misc. Paper 19. 20 pp. (In cooperation with the Department of Zoology, University of California, Davis.)

Lists 200 species, including 133 birds, which have been identified on the experimental range. Notes on abundance and importance of each species are valuable to students of range and wildlife.

Colman, E. A.
Water control and timber management. 45th Annual Western Forestry Conf. Western Forestry and Conserv. Assn. Proc., pp. 24-26.

Discusses ways in which timber production can be integrated with land management for controlling water flow in the western United States.

Colman, E. A., and Brown, C. B.
Measures needed to manage watersheds. Jour. Soil and Water Conserv. 10: 237-240.

Part 4 in a series of articles on "Protecting and Developing the Nation's Watersheds." Describes the place of upstream and downstream operations in watershed management.

Cornelius, D. R., and Talbot, M. W.
Rangeland improvement through seeding and weed control on east slope Sierra Nevada and on southern Cascade Mountains. U. S. Dept. Agr. Hdbk. 88. 51 pp., illus.

Describes range improvement measures applicable to six types of range land: Sagebrush range, dry grassland sites, mountain meadows, pine forest type, and aspen and red fir types.

Eaton, C. B.
The Saratoga Spittlebug. U.S.Dept. Agr. Forest Pest Leaflet 3. 4 pp., illus.

Describes a pest particularly destructive to pine plantations of the Lake States. Hosts, range, and symptoms of attack are covered as well as indirect control through proper establishment of plantations and direct control with DDT.

Eaton, C. B., and Lyon, R. L.
Arhopalus productus (Lec.), a borer in new buildings. Calif. Forest and Range Expt. Sta. Tech. Paper 11. 11 pp., illus.

Summarizes available information on this wood-boring pest, which can emerge from infested lumber in new buildings and can chew completely through overlying artifacts such as hardwood flooring and composition roofing. Infested lumber should be kiln-dried or channeled to uses where beetle emergence is no problem.

Firestop
Fire retardants - I. Progress Report No. 4. 12 pp. illus. (Prepared by the Station fire research staff for the Firestop Executive Committee.)

Describes laboratory procedures aimed at evaluating the effectiveness of retardants in the various ways they may affect fire.

Firestop
Fuel studies - I. Progress Report No. 5. 15 pp. illus. (Prepared by fire research staff for the Firestop Executive Committee.)

Presents a method of measuring the volume and vertical distribution of grass and chaparral fuels. Tons of green and dead fuel per acre are shown for sample plots.

Firestop
Seasonal changes in chaparral moisture. Progress Report No. 6 7 pp., illus. (Prepared by fire research staff for the Firestop Executive Committee.)

Relates variations in green foliage to topography and changes in climate. Such information, when considered along with knowledge of fluctuations in the moisture content of dead materials, can be an important aid in the prediction of forest fire behavior.

Firestop
A wind machine and fire control. Progress Report No. 8. 8 pp., illus. (Prepared by fire research staff for the Firestop Executive Committee.)

Axial-flow blowers may aid in backfiring, but the probability of spot fires and danger to the operator prohibit their use for holding a spreading fire against the wind.

Firestop
Aerial firefighting--bulk water drop by fixed wing aircraft. Progress Report No. 9. 13 pp., illus. (Prepared by fire research staff for the Firestop Executive Committee.)

Describes previous work by several agencies on dropping water and retardants on fire from aircraft and reports on water drops from a modified TBM bomber. Tests showed that a trained pilot could be led over a fire and directed to place water on a designated piece of fire line.

Firestop
Aerial firefighting--the helitanker. Progress Report No. 10. 5 pp., illus. (Prepared by fire research staff for the Firestop Executive Committee.)

Describes a helicopter equipped to combine the advantages of the tank, pump, and hose of a small ground tanker with the mobility and speed of the helicopter, and suggests uses for the helitanker on the fire line and for civil defense purposes.

Firestop
Lightweight pipe for water supply. Progress Report No. 11. 6 pp., illus. (Prepared by fire research staff for the Firestop Executive Committee.)

Describes the use of quick-coupling aluminum pipe and its suitability for rapid emergency delivery of large quantities of water to fires over relatively rough terrain and long distances.

Fowells, H. A., and Schubert, G. H.
Planting trials with transpiration retarants in California. Tree Planters' Notes 20: 19-22.

Describes several trials with transpiration retardants to increase survival of sugar pine, Jeffrey pine, and ponderosa pine planting stock. None was effective in increasing survival.

Furniss, M. M., and Hallin, W. E.
Development of high-risk trees in ponderosa and Jeffrey pine stands following sanitation-salvage cutting. Calif. Forest and Range Expt. Sta. Res. Note 94. 2 pp.

Shows the volume of high-risk timber that developed 16 to 17 years after a sanitation-salvage cutting, a process which removes the trees most susceptible to attack by bark beetles. High-risk trees made up 7.7 percent of the stand volume after 16 to 17 years, as compared with 17.2 percent of the virgin stand before sanitation-salvage operations.

Gleason, Clark H., Packer, Paul E., and Hockensmith, R. D.
Watershed damage--its signs and causes. Amer. Forests 61(6): 34-37, illus.

Describes watershed damages that may be caused by careless burning or logging or other land abuses; suggests that such damages can be avoided if signs of abuse are recognized in time.

Gordon, D. T.
A portable pole ladder. Jour. Forestry 53: 453-454. 2 pp., illus.

Describes a light weight, portable pole ladder designed by Gordon for climbing trees.

Hall, R. C.
Insect damage to the 1954 crop of Douglas-fir and sugar pine cones and seeds in northern California. Calif. Forest and Range Expt. Sta. Misc. Paper 18. 4 pp.

Analysis of Douglas-fir and sugar pine cones from several National Forests of northern California revealed an average loss by seed and cone insects of 82.2 percent of Douglas-fir and 75.1 percent of sugar pine seed.

Hellmers, Henry, Bonner, James F., and Kelleher, John M.
Soil fertility: A watershed management problem in the San Gabriel Mountains of southern California. Soil Sci. 80: 189-197.

Application of nitrogen to shallow, undeveloped soils of the San Gabriel Mountains stimulated plant growth. The resulting increase in density of vegetation may aid in reducing the normally high soil erosion rate in these mountains.

Hellmers, Henry, Horton, J. S., Juhren, G., and O'Keefe, J.
Root systems of some chaparral plants in southern California. Ecology 36: 667-678, illus.

The root systems of 68 plants, representing 18 species of shrubs and sub-shrubs, were studied. The relative importance of the different types of root systems is discussed in relation to the erosion and water-yield problems of watershed management.

Horton, J. S., and Kraebel, C. J.
Development of vegetation after fire in the chamise chaparral of southern California. Ecology 36: 244-262, illus.

Describes periodic observations of plant succession after fire on permanently marked plots through the period of rise and decline of the temporary vegetation, until the permanent shrubs again dominated the burned area.

Jemison, George M.
The forester and wood utilization. Northern Calif. Section, Soc. Amer. Foresters Proc. 1954: 1-5.

Describes interdependence of forest management and forest products industries.

Jemison, George M.
Forest management made easy. Forest Products. Jour. 5(2): 40-42A.

Outlines California's chief forest-product utilization problems and urges that forest managers and wood-utilization technicians work together to solve these problems.

Jensen, A. W., and Ely, J. B.
Air delivery of water helps control brush and grass fires. Calif. Forest and Range Expt. Sta. Forest Research Note 99. 12 pp., illus.

Describes tests of an agricultural biplane as an aerial tanker for support of ground fire-fighting forces. Water was dropped on fires on the Mendocino National Forest during the 1955 fire season, and calibration flights were made at the Willows airport dropping both water and fire retarding chemical.

Kimmey, James W.
Rate of deterioration of fire-killed timber in California. U. S. Dept. Agr. Cir. 962. 22 pp., illus.

Supplies timber owners and operators with information valuable in planning salvage of fire-killed timber. The circular gives rates of deterioration for five species and various sizes of trees. It names and evaluates the agents that cause deterioration. Conditions influencing the rate of deterioration are described, and salvage problems are discussed.

Kimmey, James W., and Lightle, Paul C.
Fungi associated with cull in redwood. Forest Sci. 1: 104-110, illus.

Two fungi cause distinct types of decay in living redwoods. One, a brown cubical rot, is most prevalent in the southern and the other, a white ring rot, is most severe in the northern part of the tree's range. These two rots cause virtually all cull due to decay in redwood stands.

Keen, F. P.
The western pine beetle. U. S. Dept. Agr. Forest Pest Leaflet 1. 4 pp., illus.

A brief account of pertinent, present-day knowledge of the most destructive insect attacking ponderosa pine. Means of recognizing the insect and its damage, its habits, and natural and direct control measures are given.

Keen, F. P.
The rate of natural falling of beetle-killed ponderosa pine snags. Jour. Forestry 53: 720-23.

Ponderosa pine snags in southern Oregon and northeastern California deteriorated and fell very slowly at first and then rapidly after about 5 years. After 15 years, 75-80 percent had fallen. Trees of larger diameter remain standing for longer periods, and hence the disposal of snags 30 inches or more in diameter is recommended.

Kraebel, Charles J.
Conquering Kennett's gullies. Amer.Forests 61(12):36-39,42, 44.

Describes the killing of forest cover by smelter fumes 50 years ago in northern California, subsequent erosion of the bared slopes, studies that developed successful methods of reforestation and erosion control, and recent application of the methods on the area.

Lightle, Paul C.
Longevity of Peridermium harknessii aeciospores stored at 40°F. Plant Dis. Reporter 39: 983-984.

Aeciospores of this gall rust retained their viability when air dried prior to low temperature storage. Fifteen percent were still viable after 14 months storage at 40° F.

Lightle, Paul C.
Experiments on control of Elytroderma needle blight of pines by sprays. Calif. Forest and Range Expt. Sta. Forest Res. Note 92. 6 pp.

Fall applications of fungicidal sprays applied in two different years failed to control the disease. Possible reasons for the failure are suggested.

Lyon, R. L.
A secondary sex character on the male of the California five-spined engraver, Ips confusus (Lec.). Canad. Ent. 87: 482-3, illus.

Describes a tiny embossment on the face of the male which is 99 percent reliable in separating the males from the females for entomological studies.

May, R. H., and Ericksen, L. N.
Wood residue from primary wood-using industries in California. Calif. Forest and Range Expt. Sta. Tech. Paper 13, 15 pp., illus.

Presents statistics gathered in a survey of sawmills and plywood plants, showing amount of wood residue produced, amount used and unused, and concentration areas where unused residue could supply raw material for new pulp industries.

May, R. H. and Sindel, G. E.
The northern outpost of the giant sequoia. Sierra Club Bul. 40(8): 70-72.

Locates and describes the most northerly grove of Sequoia gigantea.

Mirov, N. T. and Iloff, P. M. Jr.
Composition of gum turpentines of pines. XXIII. A report on three mediterranean species: Pinus pinea (cultivated in California), P. halepensis (from Israel) and P. brutia (from Cyprus.) Jour. Amer. Pharm.Assoc., Sci.Ed. 44(3): 186-189.

Gives the results of chemical analysis of oleoresins.

Mirov, N. T. and Iloff, P M. Jr.
Composition of gum turpentine of pines. XXIV. A report on two Asiatic pines: Pinus armandi and P. bungeana. Jour. Amer. Pharm. Assn., Sci. Ed. 44(7): 424-427.

Gives the results of chemical analysis of oleoresin.

Moore, A. D.
Ips confusus (Lec.) adults infected with nematodes. Jour. Econ. Ent. 48(4): 478

This insect was found to be infected with two species of nematodes, but there was no correlation between mortality among the beetles and the presence of these parasites.

Righter, F. I.
Possibilities and limitations of hybridization in Pinus. Southern Forest Tree Improvement Comm. Proc. 1955: 54-63.

Compares progress in pine hybridization to progress in synthesis of chemical compounds, outlines possibilities for crossing different species of pines, and discusses the practicability of mass-producing hybrid pines.

Righter, F. I.
Tree improvement activities at Placerville, California, affecting southern species. Southern Forest Tree Improvement Comm. Proc. 1955: 97-99.

Lists hybrids and hybrid progenies produced at the Institute of Forest Genetics from controlled pollination among southern pines.

Reifsnyder, W. E.
Wind profiles in a small isolated forest stand. Forest Sci. 289-297, illus.

Reports data on wind velocity measured in an artificially created stand of 145 ponderosa pines. Maximum attenuation of wind by tree crowns was 50 to 70 percent. Results from this model study are compared with profiles from work of other investigators.

Retzer, J. L. and Colman, E. A.
Soil surveys on forest and range lands. U. S. Dept. Agr. Yearbook 1955: 242-246, illus.

Explains the value of soil surveys and their particular uses on forest and range lands.

Rowe, P. B.
Effects of the forest floor on disposition of rainfall in pine stands. Jour. Forestry 53: 342-348.

Presents results of a series of experiments designed to: (1) measure evaporation from forest floors of pine stands in California, and (2) determine the influences of these floors on surface runoff, percolation, and evaporation from the soil.

Roy, D. F.
The Clements growth prediction charts for residual stands of mixed conifers in California. Calif. Forest and Range Expt. Sta. Tech. Paper 9. 13 pp., illus.

Alinement charts are presented by which foresters can estimate gross increment, ingrowth, and loss in residual mixed-conifer stands of the Sierra Nevada. The charts, developed from 20-year records, use several variables in stand condition immediately after logging.

Roy, D. F.
Don't plant close to unbarked logs! Calif. Forest and Range Expt. Sta. Forest Res. Note 101. 1 p, illus.

About 3 years after logging, large sheets of bark begin to slough from Douglas-fir cull logs. If covered by bark, conifer seedlings smother. Therefore, planting close to logs still holding bark should be avoided.

Roy, D. F.
Hardwood sprout measurements in northwestern California. Calif. Forest and Range Expt. Sta. Res. Note 95. 6 pp., illus.

After destruction of their aerial portions by fire or logging operations, several kinds of hardwoods produced vigorous sprouts. Sprout height growth differed by species--in descending order: bigleaf maple, madrone, Oregon white oak, tanoak, and dogwood. The parent trees of larger diameter produced more sprouts, taller sprouts, and wider clumps.

Roy, D. F.
Oregon limits of California tree seed collection zones. Calif. Forest and Range Expt. Sta. Forest Res. Note 93. 3 pp., illus.

The seed collection zones of northern California are extended into southern Oregon in order to permit obtaining seed from somewhat larger areas with assurance that seed will produce trees suited to their environment.

Schubert, Gilbert H.
Recent trials with 2,4-D and 2,4,5-T to kill brush in the Sierra Nevada in California. Calif. Forest and Range Expt. Sta. Res. Note 102. 7 pp.

Describes the results of several trials to kill mountain whitethorn, Sierra evergreen-chinkapin, bearmat, littleleaf ceanothus and greenleaf manzanita. Recommendations are presented for herbicide to use and when to treat for maximum control for each of the five shrub species tested.

Schubert, Gilbert H.
Freezing injury to sugar pine cones. Calif. Forest and Range Expt. Sta. Forest Res. Note 96. 2 pp., illus.

Immature sugar pine cones were injured by freezing during late spring of the second year. The injury resulted when the temperature dropped below 20° F. after growth had started.

Schubert, Gilbert H.
California cone crop--1955. Calif. Forest and Range Expt. Sta. Forest Res. Note 97. 3 pp.

The cone crops in California were generally fair or less throughout the state. The cone crop sizes of 15 different species are summarized by species and seed zone or county.

Schubert, Gilbert H.
Freezing injury to young sugar pine. Jour. Forestry 53: 732.

Describes injury to seedlings and transplants in the nursery and in field planting. Late spring and early fall freezes caused more damage to young seedlings than to older plants.

Schubert, Gilbert H.
Effect of storage temperature on viability of sugar, Jeffrey, and ponderosa pine seed. Calif. Forest and Range Expt. Sta. Forest Res. Note 100. 3 pp.

Seeds were stored in half-gallon cans with tight lids at 4 temperatures--0°F., 23°F., 32°F., and 41°F. Best results were obtained for sugar pine at 0°F., for Jeffrey pine at 23°F., and for ponderosa pine at 32°F.

Sinclair, J. D., and Hamilton, E. L.
Streamflow reactions of a fire-damaged watershed. A.S.C.E. Proc., Vol. 81, Separate 629. 17 pp.

Presents relations between peak flows and between storm discharges from two comparable watersheds on the San Dimas Experimental Forest before and after a fire in 1953 partially burned one of the watersheds.

Stanley, R. G., and Tracewell, T.
Manometer flask for measuring respiratory quotients. Science 122(3158): 76-7.

Describes a simple instrument for measuring the oxygen absorbed and the carbon dioxide released by a seed or tissue. These gas exchange values provide insight into the nature of respiration of the seed.

Struble, G. R.
The California five-spined engraver beetle. U. S. Dept. Agr. Forest Pest Leaflet 4. 4 pp.

Brief discussion of one of the most aggressive of pine engraver beetles, which often attacks in combination with the western pine beetle. Damage, life history, and habits are covered in a way to enable recognition of its presence. Preventative control through proper treatment of slash and applied control are discussed.

Struble, G. R., and Johnson, P. C.
The mountain pine beetle. U. S. Dept. Agr. Forest Pest Leaflet 2. 4 pp., illus.

Brief discussion of the damaging mountain pine beetle, including recognition, behavior from egg to adult, natural control by parasites, predators, and low temperature, and applied control by such means as salvage logging, chemical sprays, and solar heat.

Struble, G. R., and Hall, R. C.
The California five-spined engraver; its biology and control. U. S. Dept. Agr. Cir. 964. 21 pp., illus.

A detailed coverage of current knowledge of the California five-spined engraver. Discusses the character of outbreaks, seasonal history and habits, conditions favoring optimum brood development and outbreaks, and biological and applied control.

Talbot, M. W.
How well do you read your range? Western Livestock Jour. 33(8): 42, 87, 88, illus.

Brief non-technical discussion of clues to range condition and trend that can be seen on the ground.

Wagener, Willis W.
Heart rots in living trees. Natl. Shade Tree Conf. Proc. 1954: 227-231.

Heartwood decaying fungi fall in two groups, true heart rotters and fungi decaying primarily sapwood and dead limbs but that may also extend into heartwood. The environment within a tree affects the rate of decay.

Wagener, Willis W.
Preliminary guidelines for estimating the survival of fire-damaged trees. Calif. Forest and Range Expt. Sta. Forest Res. Note 98. 9 pp.

Outlines general principles influencing the survival of trees damaged in forest fires and suggests how these may be applied in marking timber for salvage following fire.

Woolfolk, E. J.
Range improvement and management problems in Argentina. Jour. Range Mangt. 8(6): 260-264.

Describes the range-livestock problems of LaPampa and Patagonia and suggests some improvement and management possibilities.